POWER PLANT ENGINEERING

Established Over 28 Years

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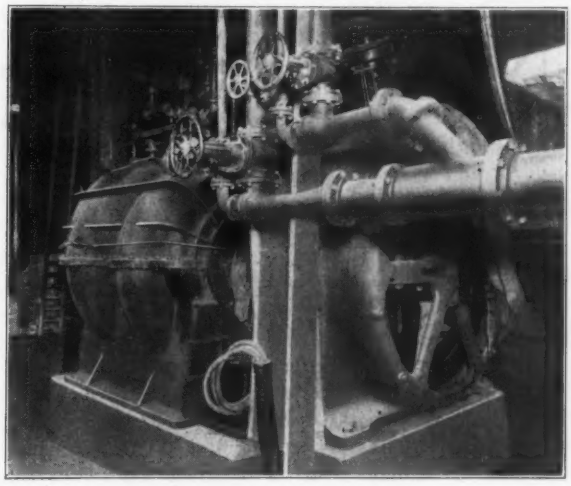


Auxiliaries Grow Up

WE HEAR MUCH these days about enormous generating units. We see all sorts of freak photographs—locomotives calmly puffing their way up draft tubes of hydraulic turbines, automobiles running races in the furnaces of water-tube boilers, horses jumping through the field coils of generators. These are interesting and enable us to visualize the proportions of modern equipment. But what about the auxiliaries?

Take a look at the photograph at the top of this column. That's one of the circulating pumps just installed at the Hudson Avenue Station. How big is it? Well, many industrial power plants in this country couldn't supply enough energy to run it. You'll find more about modern auxiliaries in the article, Motor Applications in the Boiler Room, or read the article on the Hudson Avenue Station.

HOLDING the elusive B.t.u. when they cause a steam pipe to climb above 600 deg. F. in temperature, is like trying to handle molten iron in a ladle made of lead. Ordinary insulating material simply will not stand the temperature. It shrinks, cracks, disintegrates and even chars. Somebody reasoned that refractory-lined ladles serve well in handling molten metal; why not use refractory-lined pipe covering for these red hot steam pipes? The idea looked good, investigation was started, and in this issue, Power Plant Engineering is able to report how successful this arrangement has proved to be.

Mine Mouth Plant in Indiana Just Put in Service

WABASH RIVER PLANT OF THE INDIANA ELECTRIC CORP. TRANSMITS ENERGY AT 132,000 V. 75 MI. TO INDIANAPOLIS FOR DISTRIBUTION

NOTWITHSTANDING EXTENSIVE additions recently completed at many of their several power plants, the subsidiary utility companies owned by the Central Indiana Power Co. have not, by this means, been able to keep pace with the constantly growing demands and have found it expedient to add a new super-power station to their interconnected systems.

This organization, the Central Indiana Power Co., is the holding company for the following utilities: The Northern Indiana Power Co. of Kokomo, Ind., the Merchants Heat & Light Co. of Indianapolis, the Wabash Valley Electric Co. of Clinton and the Indiana Electric Corp. which supply energy for light and power to some 125 cities and towns in a district extending to Plymouth on the north, to Marion on the east, Sullivan on the south and to the Illinois State line on the west. The last named company, the Indiana Electric Corp., in addition to furnishing service to communities and individual consumers, operates the new Wabash River Station near Terre Haute.

As an inspection of the map of the territory served by this organization will show, the plant is located on the west bank of the Wabash River, near Macksville, Ind., a little more than 7 mi. downstream from the city of Terre Haute. This site was selected by reason of such natural advantages as the adequacy of water supply for condensing purposes, accessibility for the delivery of coal directly from the mines or by rail, water or otherwise, and the location with reference to the market for, and the delivery of the power generated. The river at this point has an average minimum flow sufficient to supply the circulating water requirements for three times the contemplated future capacity of the plant, 100,000 kw. At this site the company owns some 180 acres of land along the river front which has been devoted to power plant purposes and in addition it owns some 3,276 acres of good coal land immediately adjacent which, it is estimated, contains enough coal to meet the demands of the system for more than 30 yr. to come.

This plant is being built in sections which will be added as the load may require. The present installation consists of two turbo-generators, four boilers and the necessary auxiliary equipment. No iron clad specifications have been laid out to provide for future installations and the design is such that the immediate investment includes but a minimum provision for the future and that will permit of taking advantage of any changes in power plant engineering and design of plant equipment which time may bring forth.

The present section, which has just been finished, has an installed turbine capacity of 40,000 kw. divided equally between two units. Present tentative plans call for an ultimate capacity of 100,000 kw., but this may be increased if need be to more than 200,000 kw.

INITIAL LAYOUT PROVIDES FOR A MAXIMUM OF ACCESSIBILITY

As an inspection of the plan of the station will indicate, the turbine and boiler rooms are immediately adjacent and parallel with each other, the turbine room being nearer the river. An office bay and switch house are located at the downstream end of the turbine room in order to place the electrical switching equipment as near as possible to the outdoor transformer station which, as will be noted on the map of the site, is at the downstream end of the property. The arrangement as worked out here appears to give, for this particular case, the maximum of accessibility and ease of operation in connection with a minimum of space and cost of installation.

The present section of the turbine room, housing two units, is 57 ft. wide by 153 ft. long and according to present plans the ultimate turbine room, to house five units, will be 347 ft. long. The present boiler room is 101 by 162 ft. and the ultimate will be 101 by 316 ft. This together with the switch house which is 46 by 45 ft. and the operating rooms, 32 by 57 ft., will give for the ultimate station 0.59 sq. ft. of station area per kilowatt installed. Inasmuch as there is some provision made in the present section for future needs, the present ratio is somewhat greater than this figure.

To anybody who has followed the trend of power plant engineering the constant decrease in the ratio of the size of the station to the capacity is quite marked. Such a statement unsupported by any other facts might lead one to suppose that modern stations were exceedingly cramped for room. Such, however, is far from the case; the first impression one gets in visiting such a plant is the amazing size of the place. There seems to be boundless room everywhere, all around and overhead. The firing aisle is wide but no wider than is necessary to accommodate the weigh larry; the aisle behind the boilers is also wide but only wide enough to replace tubes; the space around the turbines is ample but only sufficient to accommodate the condensers and auxiliaries below. And so it goes; there

is plenty of space but it all serves a definite and useful purpose. The reason then for this small ratio lies not in cramping the equipment but rather in the extreme compactness of the units themselves.

Building foundations and substructure are of reinforced concrete throughout. As there is a difference of some 31 ft. between low water and maximum flood levels, it has been necessary to place the condenser room floor 19 ft. below the extreme high water mark and to make the turbine room substructure in the form of a water tight compartment or concrete box; the top of this compartment, walls are of selected red brick with limestone trim and the inside turbine room walls are of ivory gray faced brick with a salt-glazed brick extending some 6 ft. above the condenser floor and 6 ft. above the turbine room platform. Red quarry tile is used exclusively on both the condenser floor and the turbine room platform.

To permit of easy handling of material, a standard gage track setting extends across one end of the turbine room on which machine parts may be brought in. A 75-T., 57-ft. span, 4-motor traveling crane with a 15-T. auxiliary hoist, the runway for which extends over the railroad spur,

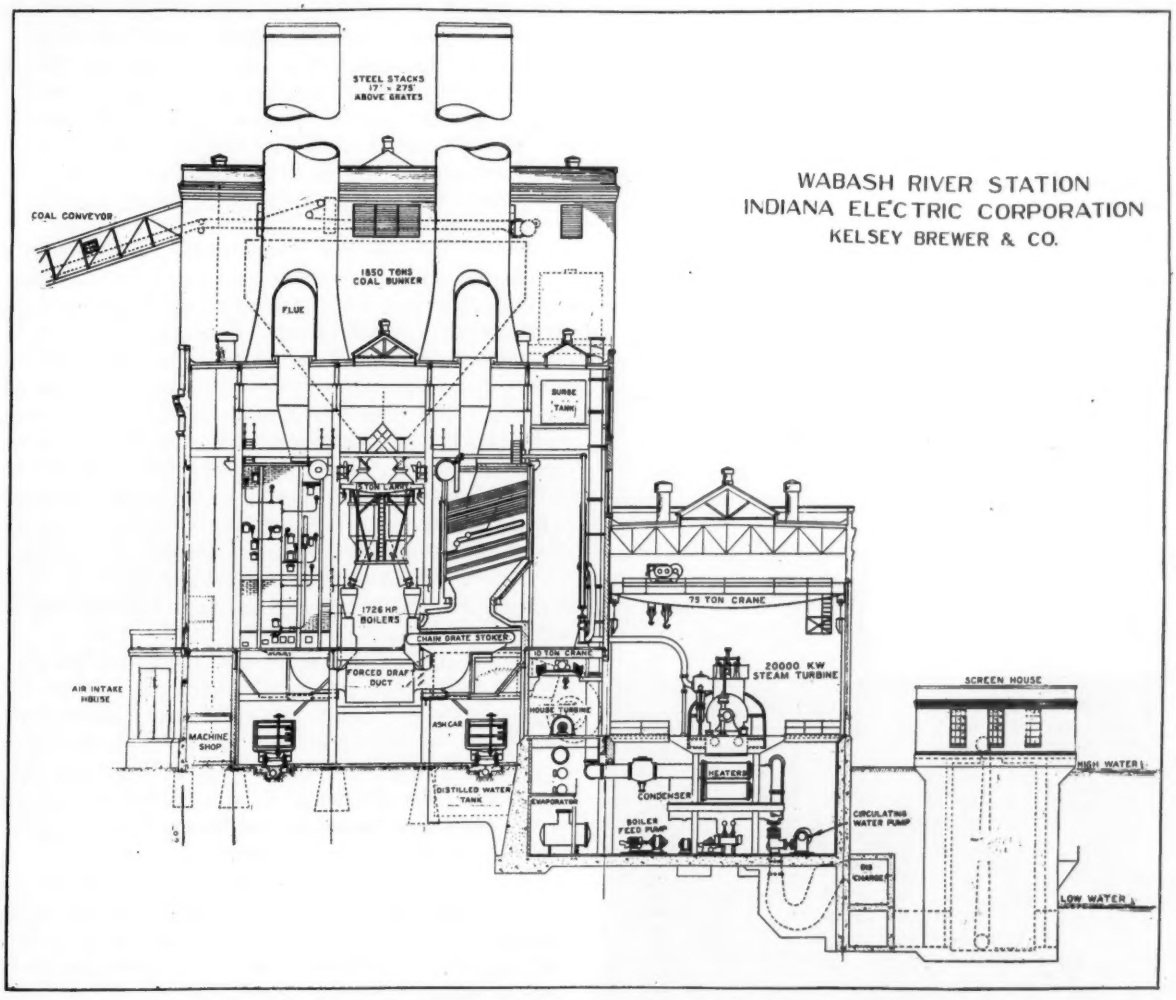


FIG. 1. TYPICAL SECTION THROUGH BOILER AND TURBINE ROOMS

at the same elevation as the turbine room floor, is 7 ft. above the highest known flood level.

To provide against flotation effect of the building during periods of high water, the condenser room floor, which is of reinforced concrete construction, has been anchored to the underlying rock formation by means of steel tie rods. The boiler room basement floor lies on the established grade of the property which is 2 ft. above the maximum flood level of record.

The superstructure is composed entirely of steel framing in connection with brick walls, concrete floors and booktile roofing supported on steel purlins. The outside serves both the turbine and condenser room floors. In addition to this there is a 10-T. traveling crane provided which serves the bay in which the house turbine is located.

In the office bay at the downstream end of the building there are four floors devoted to office space which gives ample room for office accommodations for the chief engineer, his staff and the watch engineer. Completely equipped sleeping quarters and a first aid room have been provided for use in emergencies. The upper floor of the office bay is given over to electrical operating control rooms and the load dispatcher's office. Windows in these rooms opening out into the turbine room permit a view of the

turbines and auxiliaries from the office and the operating rooms. This section of the power plant, constituting a small office building in itself, is served by a push button type elevator.

Coal Supply and Handling Equipment

Principal coal strata underlying the company's property are No. 3 and No. 5 Indiana veins which will be

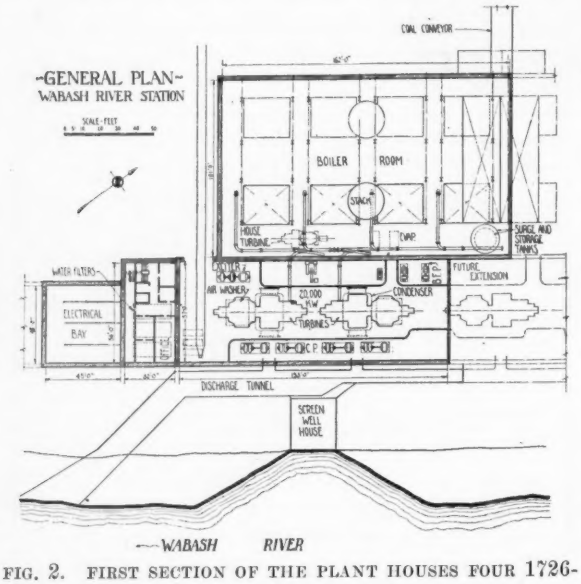


FIG. 2. FIRST SECTION OF THE PLANT HOUSES FOUR 1726-HP. BOILERS AND TWO 20,000-KW. TURBO-GENERATORS

available for use in the plant at any time in the future when it is deemed advisable to make use of them. After careful study and tests made at other of the company's plants, notably at Kokomo and Logansport, forced draft

FIG. 3. FOUR 1726-HP. BOILERS GENERATE STEAM AT 350 LB. PRESSURE AND 215 DEG. F. SUPERHEAT

chain grate stokers were chosen as the most feasible method of burning the coals that would be available.

All plans are now completed and work is started on the mine shaft but until such a time as the company's mine is developed, coal will be received over a spur track about 1¼ mi. long built to connect the site with the Pennsylvania railroad running out of Terre Haute. Cars are dumped into a hopper beneath the tracks and the coal passes then through a crusher and onto a system of belt conveyors which delivers it through an inclined runway into two overhead concrete bunkers of 1000-T. capacity each, located above the boilers at the upstream end of the present section. From this bunker the coal is delivered to the individual stoker hoppers by means of a 15-T. motor operated weigh larry. The present unloading, crushing and conveying equipments is of sufficient capacity to accommodate eight boiler units, four of which are now in service, with three additional units now being installed.

Duplicate coal handling equipment will be installed when the plant is extended to house more than eight boilers which the present building will accommodate. The track hoppers are housed in a brick building apart from the main structure, to the north and provision is made for the installation of a traveling crane and grab bucket for unloading any gondola cars that may be received. Locomotive cranes are provided for handling coal to and from storage. This storage yard, laid out on either side of the building housing the track hoppers, has a capacity of about 30,000 T.

Boiler Installation Designed for Cheap Fuel

The present boiler installation consists of four Babcock & Wilcox cross drum type boilers, each having 17,260 sq. ft. of heating surface, which are operated at 350-lb. pressure. Each boiler contains 720 tubes 4-in. diam. by 20-ft. long arranged in 36 sections, each section containing 20 tubes. The high tube banks were used rather than shorter bank in connection with an economizer because the comparatively low cost of the coal did not justify the use of economizers with their increased maintenance costs. As indicated on the cross sectional drawing of the boiler, the lower two rows of tubes are segregated from the others so as to form a kind of slag screen which provides ample entrance area for the gases of combustion, to prevent the adherence of clinker and slag.

Superheaters are installed immediately below the upper bank of tubes, i. e., between the sixth and seventh rows counting from the bottom of the header. Each unit has 2424 sq. ft. of heating surface, 14 sq. ft. per 100 sq. ft. of boiler heating surface, and is designed to furnish steam at a temperature of 650 deg. F. with the boilers operating at 200 per cent of rating and delivering steam containing not more than 1 per cent of moisture.

Boilers are set with their headers at the uptake end 21½ ft. above the floor, giving a furnace volume of approximately 4014 cu. ft. or 0.23 cu. ft. per sq. ft. of boiler heating surface and about 1 cu. ft. per boiler hp. at the normal rating of 250 per cent. The boilers are, as has been indicated, 36 tubes wide, which necessitates a furnace 21-ft. wide which, it was decided, was too wide for one stoker, if low maintenance costs were to be secured. Consequently, two Babcock & Wilcox forced draft chain grate stokers have been provided per boiler. Each is 21 ft., 3 in. long by 9 ft. 6 in. wide and has a surface of 202 sq. ft., giving a total of 404 sq. ft. per boiler or a ratio of 39.2 sq. ft. of heating surface per sq. ft. of grate surface.

Arches are placed over both the front and rear of each stoker, the front or admission arch being 8 ft. 6 in. long and the rear arch extending from the back wall to a point about mid-way over the rear combustion zone. The design of this arch is such as to throw gases containing an excess of air back towards the front of the boiler where they mix

with and tend to complete the combustion of the richer gases distilled from the green coal over the front section of the stoker. It is contemplated that this design will also decrease ash pit losses by preventing any great amount of unconsumed combustible being carried over the rear portion of the grate into the ash pit.

Furnace walls are of solid fire brick, 26 in. thick with ventilated side walls; the side walls, immediately above the grate are protected by two 4-in. tubes connected directly into the boiler circulating system. The setting stands within a structural buckstay framework designed to support and restrain the wall but to allow sufficient freedom to take care of any expansion and contraction that may develop. Heating surfaces, both boiler and superheater, are cleaned by a system of Diamond Valv-in-head soot blowers of which there are nine units on each side of each boiler setting.

Ash hoppers sufficient for a day's accumulation of ash are installed directly below each stoker combination. These hoppers are each equipped with four air operated gates from which the ash is dumped directly into railroad gondola cars, run in on a track directly below.

Forced draft is supplied by two American Blower Co. double inlet motor driven fans having a capacity each of 225,000 cu. ft. per min. at a pressure of 2 in. of water when operating at 305 r.p.m. and at 5 in. of water at 514 r.p.m., which is sufficient to meet the requirements of all four boilers operating at 225 per cent of rating. These fans discharge into a central duct running the length of the boiler room beneath the boiler room floor from which connections are made to each individual stoker. The air for combustion is supplied to the grate through a system of six wind boxes, the flow through each of which can be regulated to meet the requirements for most efficient combustion. Although they are not as yet completely installed, Hagan draft control apparatus and Ruggles-Klingeman damper regulators are being put in. A single stack with outside flues serves this battery of four boilers. This stack is of self supporting steel construction superimposed on the building framework. It is 17 ft. in diameter inside the brick lining and extends 275 ft. above the grates.

Main Generating Units Equipped for Bleeder Heating

In the section just completed, the turbine room accommodates two 20,000-kw. single cylinder Westinghouse combination impulse and reaction type turbo-generators. These units take steam at a pressure of 200 lb. and a temperature of 650 deg. F. The generators, operating at 1800 r.p.m., deliver, at rated capacity, 1100 amp. per phase at 13,200 v., 3 phase, 60 cycle. The turbines are of the new single flow type embodying all the recent improvements that have been made in Westinghouse turbine design, including the new Bauman type blading and stream line exhaust casing which has been found effective in reducing the pressure drop between the turbine and condenser.

Both units are arranged for bleeding steam for feed water heating from the third and fourth blade rings. At rated capacity approximately 25,400 lb. of steam per hour is extracted for this purpose, this quantity being sufficient to heat the condensate to an average temperature of 208 deg. F. as measured at the discharge of the second or higher pressure heater.

To keep the temperature rise of the generator within the allowable limits a Spray Engineering Co. closed system of ventilation, having a capacity of 65,000 cu. ft. of air per min., has been provided. Water for the spray nozzles of this system is supplied by two 500 g.p.m. motor driven pumps.

Excitation current for each unit is furnished by a 125-kw., 250-v. direct connected exciter, an exciter rating of 0.0625 kw. per kw. of the main unit.

Ordinarily, these turbines are operated against a vacuum of 29 in. of mercury, which is maintained by a Westinghouse condenser having a surface of 40,000 sq. ft., i. e., 2 sq. ft. per kw. served, at rating. The condenser is

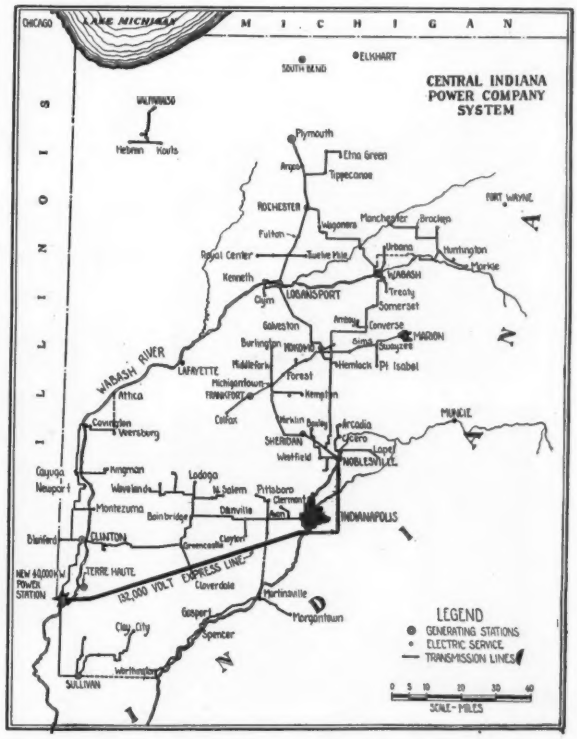


FIG. 4. TERRITORY SERVED BY THE CENTRAL INDIANA POWER CO.

of the two pass, two compartment type, enabling the turbine to be kept in operation, at a reduced vacuum, of course, while the tubes are being cleaned.

Two circulating water pumps and two hot well pumps are installed with each condenser. Three sets of air ejectors are provided for this section of the station, one set for each condenser and a standby set which is used as a spare and is common to both.

House Generator Used Only in Emergency

Ordinarily, energy for house service purposes is supplied from the main turbo-generator unit through a bank of 13,200 to 2300 v. transformers, but in case of an emergency that would cause a failure of the auxiliary supply from the main unit, power for auxiliary units may be obtained from a 2000-kw. non-condensing type turbo-generator. This unit will be kept turning at all times; the generator normally runs as a motor, the turbine being connected to the condenser of the main unit through a

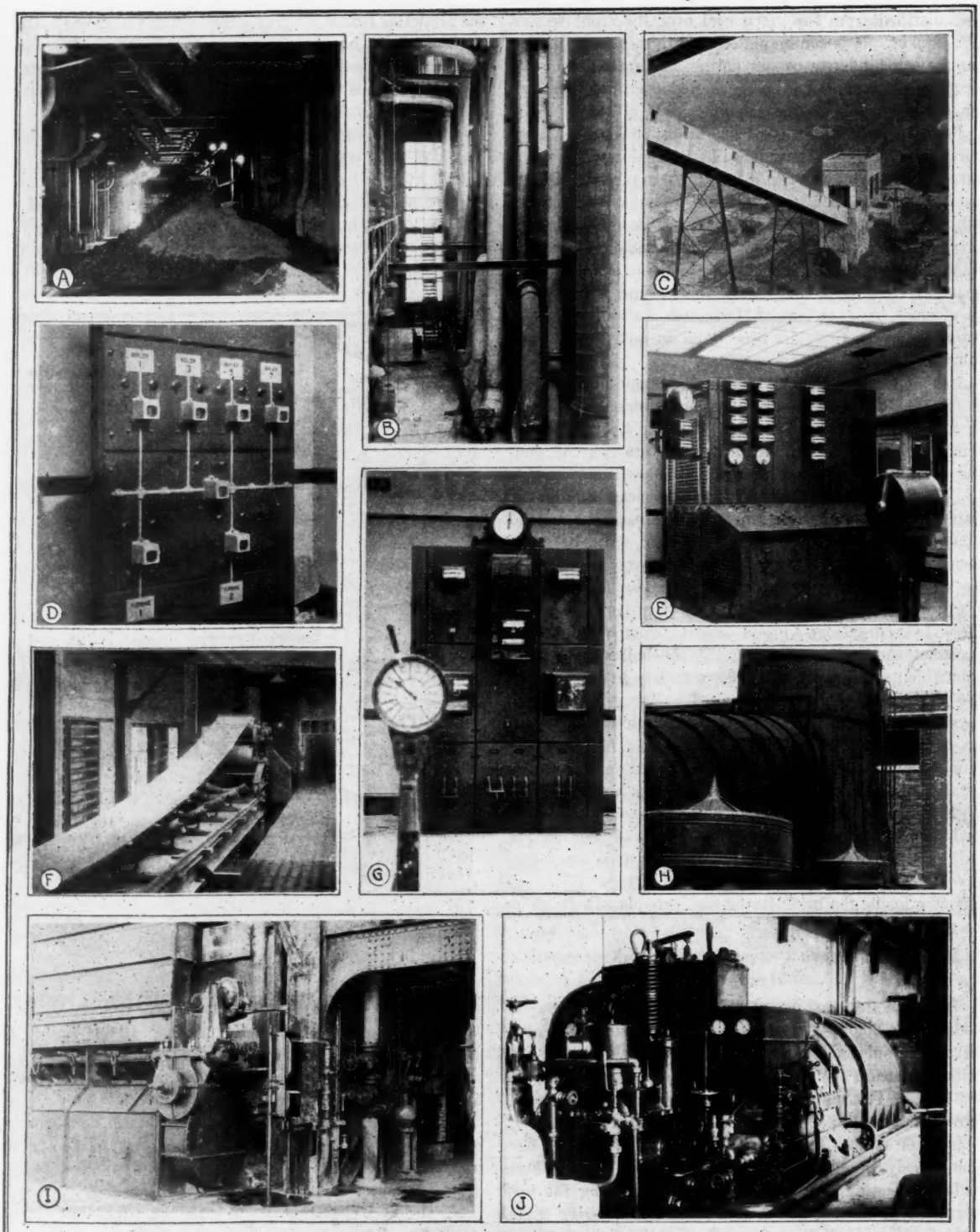


FIG. 5. HERE AND THERE AT THE WABASH RIVER STATION

A. Ash gates dump refuse directly into gondola cars run in immediately below. B. Ample provision is made to take care of expansion and contraction in the steam lines by means of loops and long radius bends. C. Track hopper building and belt conveyor for bringing coal into the plant. D. Important valves are motor operated and subject to control from the operating room. E. Benchboard type switchboard with relay panels in back. F. Belt conveyor distributes coal in the boiler room bunker. G. Totalizing meters and signal transmitting equipment. H. Drips are returned to the boilers by a Holly loop system. Condensation chambers are mounted on the stack. I. Stokers are motor driven through variable speed transmission. J. House turbo-generator floats on house-service bus.

small pipe in order to maintain a vacuum on the turbine blading.

This method of operation enables the wheels to run in a vacuum and to be maintained at a comparatively low temperature without the necessity of bleeding steam into the casing. In case of failure of the main power supply, the steam is admitted automatically to the turbine and the unit immediately picks up the auxiliary load. This method of operation possesses the further advantage that during normal operation the generator, floating on the main bus through transformers, acts as a synchronous condenser for the system which results in a higher power factor.

Make-up Is Evaporated

Inasmuch as the water available is unsuitable for use directly in the boilers, make-up water is supplied by an evaporator system. This system, having a capacity of 20,000 lb. of evaporated water per hour, is of the two-effect, high-heat-level type. The evaporator condenser is of the closed type and the discharge from the boiler feed pumps passes through it on the way to the boilers. By this means, the temperature of the feed water is raised to about 240 deg. The evaporator equipment at present in service is of sufficient capacity to serve twice the number of boilers that are now installed.

A concrete storage tank of 50,000-gal. capacity located under the ash room floor serves as reservoir for the make-up water. Provision has been made for the installation of deaerator equipment, but at present, none is installed.

To prevent any unnecessary accumulation of silt in the make-up water evaporators, the plant is equipped with a system of sand filters, located on the condenser floor under the office bay, through which all water passes on its way to the evaporators.

Two bleeder heaters are provided in connection with each turbine. Condensate from the main condenser passes in order through the oil coolers, air ejector condensers and bleeder heaters to a surge tank in the boiler room about 95 ft. above the boiler feed pumps which are on the condenser floor. An auxiliary closed heater is provided for use when either the steam driven feed pump or the exciter is in operation and exhaust steam is therefore available for heating. Under such conditions, one of the bleeder heaters may be entirely shut off or its steam supply restricted to give a feed temperature at the suction of the pumps of about 210 deg. F. From the boiler feed pumps the feed water passes through a closed high pressure heater which also serves as the evaporator heater to the boiler feed mains. From these mains there are two 4-in. connections to each boiler, both being equipped with Stets feed water regulators and a Venturi meter connection.

With the exception of one 500-gal. per min. boiler feed pump, one fire pump, and a spare 150-kw. exciter, all auxiliaries in the plant are electrically driven. These units are all for use only in emergencies, consequently for normal operation all steam for feed water heating purposes is bled from the main turbine units.

Circulating Water Is Handled Economically

Circulating water tunnels, one intake and one discharge, immediately outside the turbine room wall, supply all condensing water for the two units now in service. As the Wabash River carries, especially at flood tide, a considerable quantity of trash, leaves, etc., special care has been taken to prevent any great quantity being drawn into the tunnels and thence into the condensers. In addition to racks and emergency screens, inlet traveling screens are installed in the screen house at the mouth of the tunnel to catch any refuse that may be present.

Circulating water connections between the pumps and the condensers which they serve are exceedingly short and direct, thus reducing to a minimum the dynamic head against which the pumps must operate. As a further aid in decreasing the pumping head through the circulating system, the discharge connections from the condenser are designed as draft tubes so as to convert a considerable portion of the velocity head into pressure head. The control valves on this line are motor operated and are equipped for remote control.

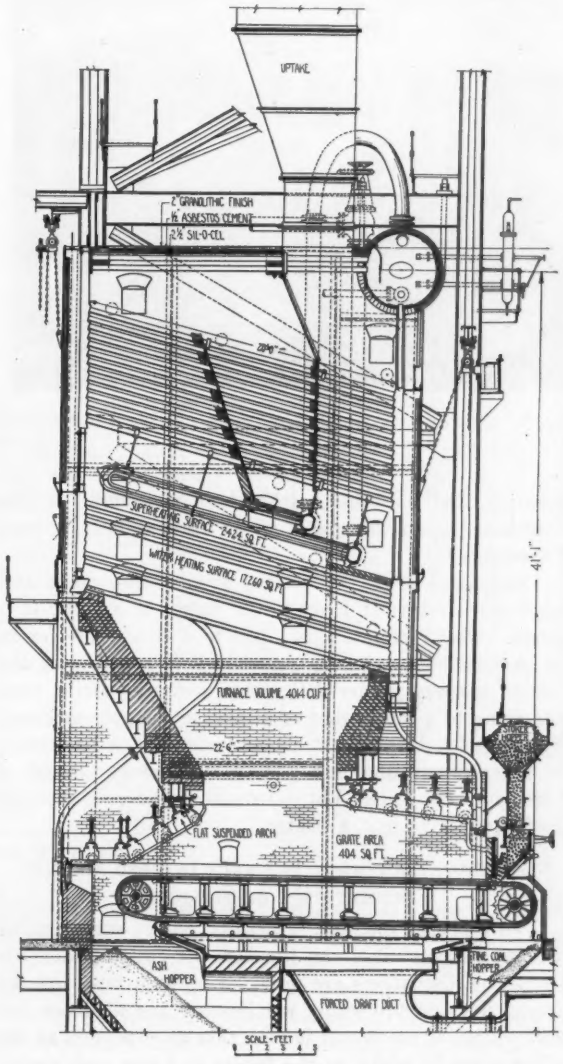


FIG. 6. HIGH TUBE BANK IS USED BUT THERE IS NO ECONOMIZER

All piping has been laid out with the idea of obtaining the maximum of simplicity without in any way endangering continuity of operation. The high pressure steam system is simple and direct. The number of flanged joints

has been reduced to a minimum by the use of telescopic type line welds and interlocking type welded nozzle outlets. Where joints have been found necessary, they are of the Sargol type. A 10-in. angle type d.c. motor operated non-return valve equipped for remote control from the operating room is installed at each superheater outlet. The sectionalizing valves in the 16 in. main header as well as the valves in each of the two turbine leads are also motor operated and remote controlled; in this case, however, alternating current is used. Each motor operated valve has two control stations, one at the valve itself for normal

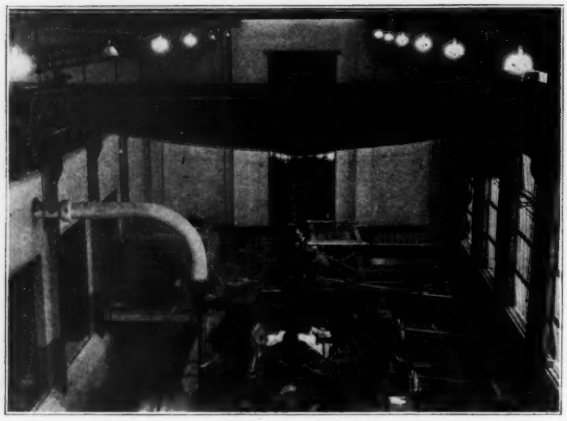


FIG. 7. ONE OF THE 20,000-KW. TURBINES WHICH HANDLE THE PRESENT LOAD

operation, and the other, as has been mentioned, in the switchboard operator's room, which is used only in case of emergency.

Condensate from the various steam lines, traps and separators is returned direct to the boilers by a Holly loop system. This condensate is piped to a closed receiver in the basement of the plant from which it is forced in the form of a spray, under full steam pressure, into a riser connecting to a condensing or discharge chamber mounted on the stack. Here the steam and moisture is separated, the water gravitating into a drop leg, thence through a U trap into the boilers and the steam discharging through a reducing valve into a heater.

Electrical Equipment Is Amply Insured Against Interruption of Service

Two 3-phase, 13,200-v. generator busses are provided with two selector oil circuit breakers per circuit. Electrolytic static dischargers are provided on each bus. At the present time no protecting reactors are installed but the arrangement of the layout is such that an extension to the building can be added in the future to house such equipment.

The electrical structure consists of two sections; the first, that adjacent to the turbine room, consists of offices on the first two floors, conduit room and load dispatching room on the third floor and a chart room and switchboard control room on the top floor. Both the switchboard room and the dispatcher's room are provided with large windows overlooking the turbine room. In the second section, oil circuit breakers and busses are provided in duplicate, the first floor containing one main 13,200-v. bus, the second floor, one set of oil circuit breakers, the third floor the second generator bus and the top floor the second set of breakers.

Oil circuit breakers installed have a breakdown capacity of 34,000 amp. at 13,200 v. and are sufficient for a generator capacity of 125,000 kv.a., without the use of external reactors.

Both generator and transformer circuits are provided with relay protection, the generator relays being also connected to trip the main steam throttles on the turbines, the neutral switch and the field switch.

A bus discharger is connected to each of the main busses, and in the future one will be connected to each bus section.

The main control room contains a benchboard type of switchboard with relay panels in back, for the generators, station service circuit and future bus sectionalizing apparatus and a similar board facing this one for outgoing

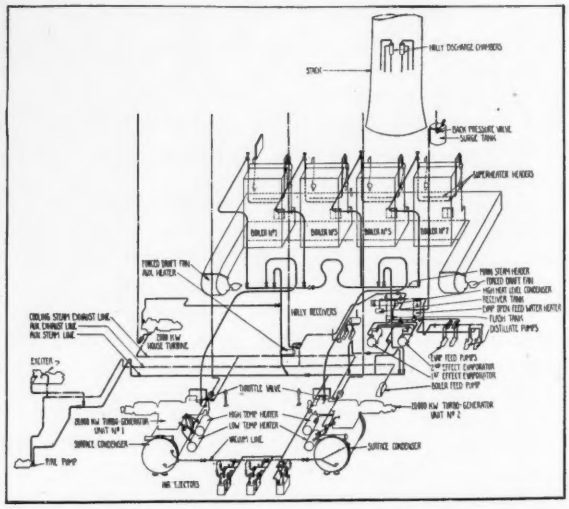


FIG. 8. STEAM PIPING SYSTEM IS SIMPLE AND DIRECT

feeder circuits. Between these two and at one end is located a station service instrument board with totalizing recording meters, d.c. control circuit switches and such equipment.

To enable the chief engineer to keep in constant touch with his operators, a signal system is provided, operated from direct current and arranged with one transmitting equipment in the switchboard control room and a receiver at each generating unit. These signal devices are similar to the control standards used in ship pilot houses. Load bulletins are provided in both the turbine room and the boiler room, operated from the switchboard control room and so constructed that the load on the station will always be automatically indicated through a connection to the station totalizing wattmeter.

In addition to indicating the total load to the operator, the station totalizing wattmeter on the instrument board causes a similar indication on meters in the boiler room, turbine room and the chief engineer's and load dispatcher's offices. There is also an additional hand on these meters in both the turbine and boiler room controlled by the switchboard operator, which indicate an anticipated load. By means of these load bulletin indicators advance notice of expected load changes can be given to the operating crew to enable them to prepare to pick up the load.

All control and instrument wiring is terminated in a conduit room located directly under the switchboard room. This construction permits the use of flexible connections to the benchboards and possible rearrangements with a minimum amount of disturbance.

Ultimately, there will be two 2500-kv.a. banks of station power transformers, and in case of failure of a transformer or any interruption to the supply of energy to the 2300-v. station bus, the house turbine generator will automatically be brought into service for the operation of relays.

All the larger motor driven auxiliary units are operated at 2300 v. and the smaller motors, at 440 v., three phase. The service feeders for these motors are so grouped regulator on the air duct. The boiler feed motors are of the slip ring type and are automatically controlled by a regulator attached to the steam and feed water systems.

Smaller and less important 440-v. 3-phase motors are fed from two 450 kv.a. transformer banks through two single distribution busses. There is an emergency tie between these busses, as one transformer bank is sufficient to carry the total load.

Lighting and Communication Has Been Developed to a High Degree

Particular study has been given to the question of lighting and in addition to the alternating-current system, certain outlets are connected to the storage battery

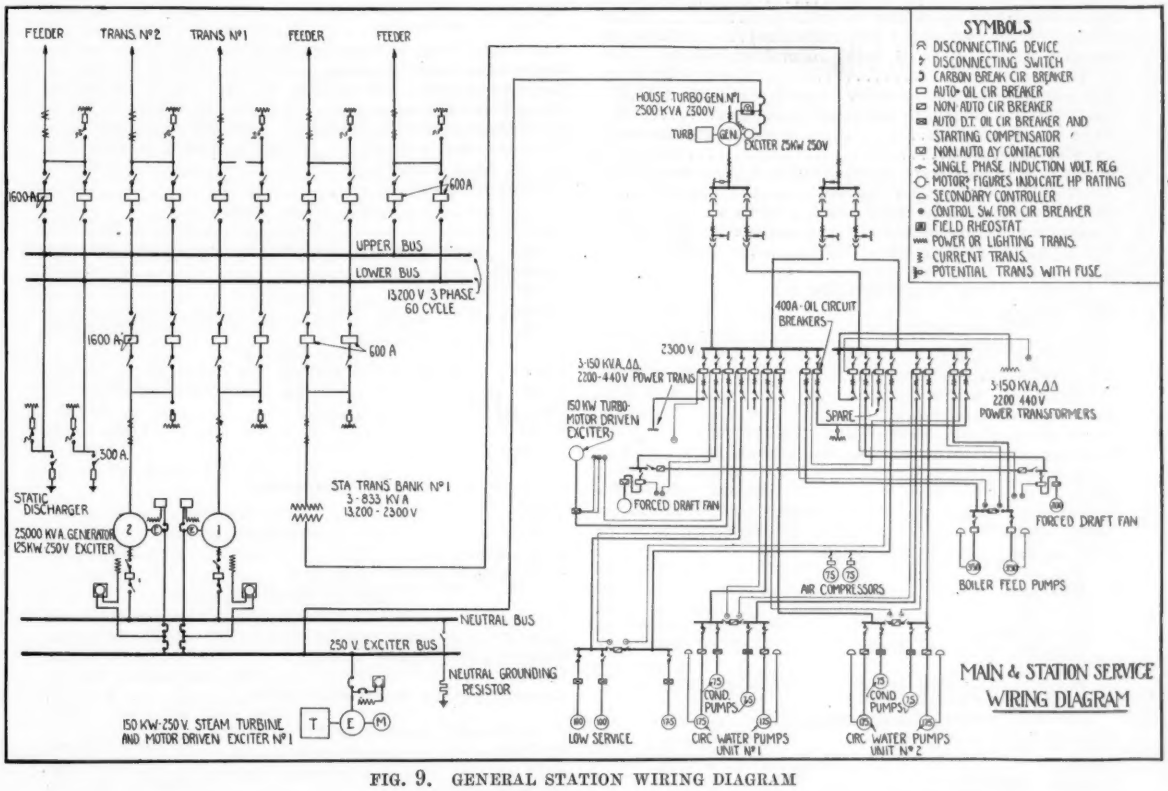


FIG. 9. GENERAL STATION WIRING DIAGRAM

that there are always two feeders available for any important service.

Circuits from the house turbine and from the transformer bank are brought out to separate busses, from which duplicate feeders run to two 2300-v. distribution busses. The circuits to the distribution busses are controlled from truck type switchboards located on the turbine room floor in the house turbine bay. The distribution oil circuit breakers are cell mounted, and electrically operated.

Motors for the main 2300-v. auxiliaries and the starting and control panels for groups of motors are located together on the condenser floor. Each group is provided with one circuit to each main distribution bus, thus providing two sources of supply. The 2200-v. motors are of the squirrel cage induction type with the exception of those driving the forced draft fans and boiler feed pumps.

Of these, the fan motors are of the brush shifting commutator type and are automatically controlled by a with automatic throwover devices so that in case of failure of the alternating current system there will be sufficient lights connected to the battery to operate the station. The lighting circuit is a 220-110-v. 3-wire system fed from a 50-kv.a. transformer through an automatic voltage regulator from each 2200-v. bus. Emergency lighting circuits carry about 25 per cent of the lighting and are normally connected to the a. c. circuit but are automatically connected to a storage battery circuit upon failure of the a. c. supply.

Energy for control circuits, valve motors, signals and emergency lights is provided by a 60-cell, 40-amp. storage battery.

Annunciators are located in the turbine room and in the switchboard control room, which will indicate automatically any interruptions on the auxiliary equipment, automatic opening of oil circuit breakers, operation of temperature alarms or other similar occurrences that require

Summary of Mechanical Equipment in Central Indiana Power Co. Plant

Stone and Webster, Inc.....Engineers and Contractors

Boilers and Superheaters

Make of boilers	Babcock & Wilcox Co.
Type	Cross drum, water tube
Number installed	4
Number, ultimate	16
Boiler pressure, gage	350 lb.
Water heating surface, each	17,260 sq. ft.
Diameter of drum	54 in.
Size of tubes	4 in. No. 7, B. W. G.
Length of tubes	20 ft.
Number of sections	36
Number of tubes per section	20
Width of furnace	21 ft. 4 in.
Grate area, projected per boiler	404 sq. ft.
Ratio water heating surface to grate area	42.7:1
Water heating surface per kw. (ultimate)	2.76 sq. ft.
Heating surface per sq. ft. boiler room floor area (ultimate)	8.64 sq. ft.
Ratio furnace volume to water heating surface	0.23:1
Ratio furnace volume to projected grate area	9.93:1
Make of superheaters	Babcock & Wilcox Co.
Type of superheater	Convection
Location of superheaters	Between 6th and 7th rows of tubes
Superheating surface per boiler	2,424 sq. ft.
Ratio superheating to boiler heating surface	14:100
Steam temperature at 225 per cent rating	650 deg. F.
Corresponding to a superheat of	215 deg. F.

Stokers

Make of stoker	Babcock & Wilcox Co.
Type	Forced draft chain grate
Number per boiler	2
Effective length, each stoker	21 ft. 3 in.
Width of each stoker	9 ft. 6 in.
Grate area of each stoker	202 sq. ft.
Chain speed at maximum rating	44.0 ft. per hr.
Coal burned per sq. ft. of grate at maximum rating	41.2 lb.
Each stoker driven by	3 hp. ind. motor
Make of motor	General Electric Co.
Stoker speed control by	Reeves variable speed transmission
Stoker arches by	American Arch Co.
Coal Burned No. 5 Vein Indiana:	
Ash	14.40 per cent
Moisture	8.50 per cent
Volatile	38.30 per cent
Fixed carbon	38.30 per cent
Calorific value (as fired)	11,160 B.t.u.
Sulphur	3.62 per cent
Fusing temperature of ash	1,900 to 2,000 deg. F.

Chimneys

Type	Self supporting steel
Made by	Chicago Bridge & Iron Works
Number installed	1
Number, ultimate	4
Height above boiler room floor	275 ft.
Diameter at top, inside of lining	17 ft.
Lining	Radial brick
Furnished by	Link-Belt Co.
Chimney supported on	Building steel framework

Coal Handling

Type	Belt conveyor, 24 in. wide
Furnished by	Link-Belt Co.
Capacity installed	100 T. per hr.
Capacity, ultimate	200 T. per hr.
Speed of belt at rated capacity	300 ft. per min.
Crusher, type	30 in. by 36 in., two roll
Crusher, make	Link-Belt Co.
Crusher, capacity	100 T. per hr.
Overhead bunker, type	Concrete
Capacity installed	1,000 T.
Capacity, ultimate	2,000 T.
Coal distributed to boilers by	15-T. weigh larry
Larry furnished by	Stephens-Adamson Mfg. Co.
Coal storage yard	30,000 T.
Reclaimed from storage	Locomotive crane and railroad cars
Locomotive crane, make	Link-Belt Co.
Yard locomotive, saddle tank type	American Locomotive Co.

Turbo Generators

Main Units

Manufacturer	Westinghouse Elec. & Mfg. Co.
Type	Combined impulse and reaction
Number installed	2, 20,000 kw. each
Number, ultimate	5, 20,000 kw. each
Pressure at bleed points at 20,000 kw.	5.6 and 16.4 lb. abs.
Capacity per sq. ft. turbine room floor area (ultimate plant)	5.06 kw.
Speed	1800 r.p.m.
Weight per kilowatt	38.2 lb.
Pressure at throttle	300 lb.
Temperature at throttle	650 deg. F.
Vacuum	29 in. mercury

	16,000 kw.	20,000 kw.
Water rate (with no bleeding)	10.08 lb.	10.21 lb. per kw. hr.
Water rate (with bleeding)	10.40 lb.	10.65 lb. per kw. hr.
Steam at condenser with bleeding	9.24 lb.	9.38 lb. per kw. hr.

Type of generator	3 phase, 60 cycles, 13,200 v.
Ventilating air for generators	65,000 cu. ft. per min.
Drive for main exciters	Direct connected to main unit
Size of main exciters	125 kw.
Excitation voltage	250 v.

Emergency House Generator

Manufacturer	Westinghouse Elec. & Mfg. Co.
Type	Non-condensing combination impulse and reaction
Capacity	2,000 kw.
Number installed	1
Number, ultimate	2
Speed	3,600 r.p.m.

Spare Exciter

Type	Combination turbine and motor drive, 250 hp.
Make	The Terry Steam Turbine Co.
Capacity	150 kw.
Speed	1,200 r.p.m.
Voltage	250 v.

Condensers

Type	Surface, two compartment
Manufacturer	Westinghouse Elec. & Mfg. Co.
Tube surface, each	40,000 sq. ft.
Tube surface per kw main unit	2.0 sq. ft.

Circulating Water Pumps

Number	Two per condenser
Capacity, one pump running	25,000 g.p.m.
Capacity, two pumps running	40,000 g.p.m.
Drive	Slip ring motor, 175 hp.
Capacity per kw. main unit	2 g.p.m.

Condensate Pumps

Number	Two per condenser
Type	Two-stage
Capacity, each	315,000 lb. per hr.
Drive	Squirrel cage motor, 75 hp.

Air Eductors

Number	One set per condenser with one common set for spare
Each set consists of	Two 2-stage ejectors with surface type intercooler and after condenser

Screen Wells and Intake Tunnels

Screen wells, number installed	1
Screen wells, number, ultimate	2
Type of screens	Traveling
Make	Link-Belt Co.
Number per screen well	2
Width, each screen	8 ft. 6 in.
Travel	15 ft. per min.

Miscellaneous Equipment

Forced Draft Fans

Number installed	2
Number, ultimate	5
Make	American Blower Co.
Type	Double inlet, full housed angular top discharge
Capacity	225,000 cu. ft. per min.

Mechanical Equipment in Central Indiana Power Co. Plant—(Continued)

Discharge pressure, in. water.....2 in. at 305 r.p.m.
Discharge pressure, in. water.....5 in. at 514 r.p.m.
Driven by.....200 hp., 16-pole, G. E. motor

Boiler Feed Pumps

Number installed 3
Type.....Jeannesville double suction centrifugal
Capacity.....Two 1,000 g.p.m.; one 500 g.p.m.
Discharge head.....425 lb. per sq. in.
Number of stages.....4
Make.....Worthington Pump & Machinery Co.
1,000 g.p.m. pumps driven by.....
.....350 hp. phase wound slip ring, variable speed Westinghouse induction motor, 1,800 r.p.m.
500 g.p.m. pump, driven by.....
.....Westinghouse non-condensing turbine, 2,200 r.p.m.
Type.....Two effect, high heat level
Make.....The Griscom-Russell Co.
Capacity.....20,000 lb. per hr.

Bleeder Heaters

Number.....Two for each 20,000 kw. turbine
Type .....Closed
Make.....Westinghouse Elec. & Mfg. Co.
Tube surface....primary, 925 sq. ft.; secondary, 900 sq. ft.

Generator Air Coolers

Type.....Water sprays, closed recirculating system
Capacity for each 20,000 kw. unit.65,000 cu. ft. air per min.
Make.....Spray Engineering Co.

Supply Pumps

Two 500 g.p.m., motor driven.....Morris Machine Works
.....Westinghouse Elec. & Mfg. Co.

Discharge Pumps

Two 500 g.p.m. vertical motor driven..Morris Machine Works
.....Westinghouse Elec. & Mfg. Co.

Service Pumps

Two 1,500 g.p.m., motor driven.....
.....Worthington Pump & Mchry. Corp.
.....Westinghouse Elec. & Mfg. Co.

Fire Pump

One 1,500 g.p.m., turbine driven.....
.....Worthington Pump & Mchry. Corp.
.....Westinghouse Elec. & Mfg. Co.

Clean Drip Pumps

Two 300 g.p.m., vertical motor driven.....
.....Morris Machine Works
.....Westinghouse Elec. & Mfg. Co.

Dirty Drip Pumps

Two 100 g.p.m., vertical motor driven.....
.....Morris Machine Works
.....Westinghouse Elec. & Mfg. Co.

Water Filters

Three 500 g.p.m. each, sand, pressure type.....
.....Roberts Filter Mfg. Co.

Screen Well Pumps

Two 900 g.p.m., vertical motor driven.....
.....Morris Machine Works
.....Westinghouse Elec. & Mfg. Co.

Turbine Room Cranes

One 75-T. capacity, 57-ft. span, 4 motor.....
.....Northern Engineering Works
One 10-T. capacity, 10-ft. span, 1 motor.....
.....Northern Engineering Works

Oil Filtering Systems

For each main turbo-generator. Partial filtration, continuous by-pass system.....S. F. Bowser & Co.
For general service:
One centrifugal oil filter...De Laval Steam Turbine Co.

Air Compressor

One 380 cu. ft. per min., motor driven..Ingersoll-Rand Co.
.....Westinghouse Elec. & Mfg. Co.
8 4-in. "Stets" type B, feed water regulators.....
.....The Williams Gauge Co.
8 4-in. Venturi meters for boiler feed.....
.....Simplex Valve & Meter Co.
2 10-in. Venturi meters for boiler feed.....
.....Simplex Valve & Meter Co.
Safety valves .....Consolidated
Blow-off valves.....Babcock & Wilcox Co.
Blow-off cocks.....Everlasting
Soot blowers (18 per boiler).....
.....Diamond Power Specialty Corp.
Fire brick and clay.....A. P. Green & Co.
Arches.....American Arch Co.
Bonding tile.....Babcock & Wilcox Co.
Smoke flue and forced draft ducts.....
.....Terre Haute Boiler Wks. Co.
Boiler room and office bay elevators.....Otis Elevator Co.
Cast iron ash hoppers and ash gates.....
.....The Allen-Sherman-Hoff Co.
Muntz metal condenser tubes.....Bridgeport Brass Co.
Circulating water valves....The Chapman Valve Mfg. Co.
Rubber expansion joints.....U. S. Rubber Co.
Copper expansion joints.....E. B. Badger & Sons Co.
Special circulating water castings..Lumsden & Van Stone Co.
High pressure steam pipe and fittings.....
.....Pittsburgh Valve, Foundry & Construction Co.
High pressure steam gate valves.....Crane Co.
Boiler non-return valves.....
.....Pittsburgh Valve, Foundry & Construction Co.
Sargol welded joints, under license from.....
.....Pittsburgh Piping & Equipment Co.
Low pressure steam and water gate valves.....
.....The Chapman Valve Mfg. Co.
Atmospheric relief valves.....Atwood & Morrill Co.
Cooling equipment for drinking water.....
.....Automatic Refrigerating Co.
Surge and storage tanks.....Terre Haute Boiler Wks. Co.
High pressure water valves.....
.....Pittsburgh Valve, Foundry & Construction Co.
Operating and control mechanism for motor operated valves.....Payne Dean, Ltd.
Structural steel.....McClintic-Marshall Co.
Steel sash and sash operators.....Truscon Steel Co.
Louvres and ventilators.....E. Van Noorden Co.
Skylights.....G. Drouve Co.

Electrical Equipment

Equipment	Type	Manufacturer
Turbo-generators	25,000 kv.a., 3 phase, 13,200 v., 60 cycle, 1800 r.p.m.	Westinghouse
House turbo-generator	2,500 kv.a., 3 phase, 2,300 v., 60 cycle, 3600 r.p.m.	Westinghouse
Spare exciter	motor and turbo driven, 150 kw., 250 v.	Terry-General Electric
Station service transformers	2500 kv.a., delta bank self cooled, 13,200-2200 v.; 450 kv.a., delta bank self cooled, 2200-440 v.; 50 kv.a., self cooled, 2200-200/110 v.	Westinghouse
Bus supports	13,200 v., smooth, white, 5 in. diameter, porcelain	Electrical Engineers Equip. Co.
	2,300 v., brown, corrugated, 4 in. diameter, porcelain	Electric Power Equipment Co.
Floor bushings	smooth, white porcelain	Locke Insulator Mfg. Co.
Entrance bushings	in pre-cast slab in iron frame	Locke Insulator Mfg. Co.
Oil circuit breakers—		
	13,200 v.	General Electric Co.
	2200 v., main, truck type	General Electric Co.
	2200 v., distribution	General Electric Co.
	2200 v., motor control	General Electric Co.
	440 v., distribution	General Electric Co.
Switchboard panels		General Electric Co.
Bus dischargers, oxide film arrester		General Electric Co.
Lighting regulator, automatic		General Electric Co.
Forced draft fan motors, brush shifting commutator		General Electric Co.
Boiler feed pump motors, slip ring		Westinghouse
Storage battery, 60 cell, 40 amp		Electric Storage Battery Co.
Battery motor generators, 10 kw., 15 hp		General Electric Co.
Interior telephone system, automatic		Automatic Electric Co.
Switchboard and turbine signal system, pedestal, motor driven		Charles Cory & Sons, Inc.
Emergency valve control switchboard, push button, remote control		Payne Dean, Ltd.

immediate attention of the operators. In addition to the usual connections to the public telephone system, an automatic intercommunicating telephone system and watchman's clock system is provided.

Because of the uncertainty of the long distance telephone service under adverse weather conditions elaborate means have been provided for maintaining communication between stations. The load dispatcher's room is provided with a Westinghouse duplex carrier wave telephone system by means of which the dispatcher can talk to any plant on the system. By means of this system, radio frequencies, modulated by voice currents, are superimposed on the high voltage transmission frequencies through capacity coupling between the transmission line and an aerial about 1000 ft.

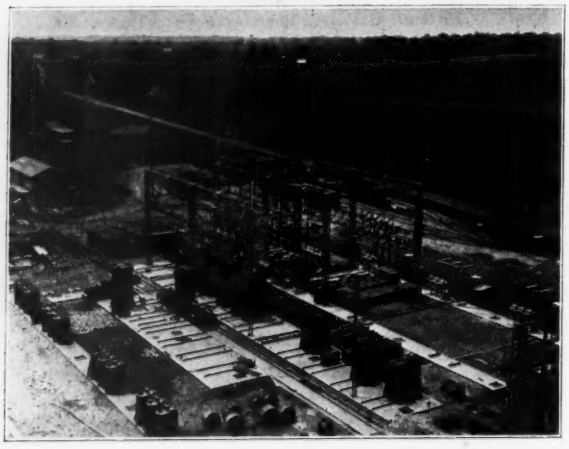


FIG. 10. OUTDOOR SUB-STATION ADJACENT TO THE ELECTRICAL BAY

long strung immediately above. The radio frequency waves are thus transmitted along with the power waves to a similar capacity coupling at the receiving end. Each station on the system has two aerials, one for sending and one for receiving. They may both be operated simultaneously, a feature which permits the dispatcher to talk and listen at the same time, i.e., just as in an ordinary telephone conversation.

Third Unit is Already Ordered

The construction program for 1924 calls for the installation of the third 20,000-kw. turbine, which will be of the same design as the two now in place, with the condenser and all necessary accessories including an extension of the turbine bay. Part two of this program calls for a switchboard for the No. 3 turbine and in addition switching equipment for the low side of two additional 25,000 kv.a. transformer banks. This will require a 40-ft. extension to the present electrical bay.

With this equipment installed the plant will be able to handle a load of 60,000 kw.

To L. B. Andrus, chief engineer of the American Public Utilities Co. and the Central Indiana Power Co., to Mr. Lyons and Mr. Bredahl, superintendent and assistant superintendent of the station and to Stone and Webster, Inc., who designed and built this plant, we acknowledge indebtedness for the courtesy and co-operation extended us in getting together the necessary data for this description.

Irregular Boiler Feeding Lowers Efficiency

Hand Feeding Is Guesswork; Automatic Regulators Give Uniform Feeding and Save Labor. By John D. Morgan

IN THE grand old days it was generally assumed that there was an art in feeding water to the boilers and with this idea in mind, practically every plant had a water tender. The water tender would not allow anyone to tam-

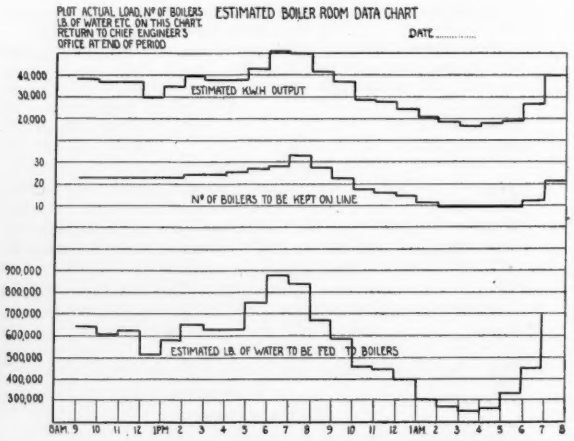

PLOT ACTUAL LOAD, Nº OF BOILERS LB. OF WATER ETC. ON THIS CHART. RETURN TO CHIEF ENGINEER'S OFFICE AT END OF PERIOD
ESTIMATED BOILER ROOM DATA CHART
DATE.....
40,000
30,000
20,000
ESTIMATED KW.H. OUTPUT
30
20
10
Nº OF BOILERS TO BE KEPT ON LINE
900,000
800,000
700,000
600,000
500,000
400,000
300,000
ESTIMATED LB. OF WATER TO BE FED TO BOILERS
8AM. 9 10 11 12 1PM 2 3 4 5 6 7 8 9 10 11 12 1AM 2 3 4 5 6 7 8

FIG. 1. AN ESTIMATED LOAD CURVE WILL AID BOILER ROOM FORCE IN PREPARING FOR LOAD CHANGES

per with the feed valve. This procedure was right and proper, for it is of vital importance to the safety of the plant as well as to the economical operation of the plant. By improper feeding of water to the boiler, it is possible to lower the normal efficiency of the boiler plant from 3 to 10 per cent below what it should be.

Proper feeding of water to boilers is a complex job. It embraces the careful study of the fire conditions, the load demand and uniform feed water pressure and temperature.

Disadvantages of the usual methods can be put forth in many ways, but the main disadvantages are that of the human element and lack of proper training methods coupled with a lack of modern regulating equipment.

Hand feeding as conducted in the average plant is a veritable guess work plan. There is, as a rule, no load indicator in the boiler room other than that of previous experience. Water is fed to the boiler when the water in the glass shows below a certain level. This level is different for each individual water tender; some always carry high water, others always carry low water. Where some watch is kept on the amount of coal or water used, it is common practice toward the end of the watch for the water tender to feed more or less water than is necessary in order to make the pound of water per pound of coal factor indicate that his particular shift is by far the most efficient.

In some plants the water tender is the real boss, for when the fireman is faced with a demand for more steam and the pressure starts downward, it is within the power of the water tender to make the task of pressure recovery an easy one by shutting off the water supply, or make it next to the impossible for the pressure to be recovered by keeping on a strong feed.

To train the water tender properly requires the expenditure of some little money and considerable time. The first expenditure of money should be made for the purchase of a good feed water pump, pressure regulator. This is one of the most important pieces of equipment, for without proper pressure regulation, proper feeding is impossible. The next valuable equipment needed will be that of a steam flow meter and water flow meter (chart recording type).

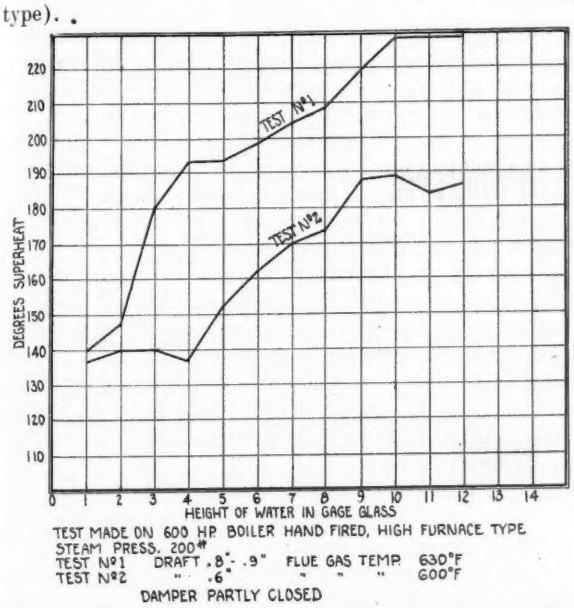


FIG. 2. SUPERHEAT VARIES WITH WATER LEVEL CARRIED

These two meters are a most valuable aid to proper and uniform water feeding. When possible, each boiler should be equipped with meters; however, if it is hard to obtain an authorization for this, fairly good results will be obtained by having one set of meters on the entire plant.

Next to the meters, the item which has great importance on the proper feeding of water to boilers, is that there should be one gage glass on each boiler drum. It has been demonstrated many times that where there is only one gage glass on a two- or three-drum boiler, one of the drums will show an exceedingly low level of water, while one of the other drums will show the water actually slopping over into the steam line.

The boiler room should be given a chart showing the approximate demand load expected on the station, and also the number of boilers to be kept on the line for this service, and in addition a visible load indicator showing the actual load at all times. An example of such a chart is given in Fig. 1.

There is also an important relation which exists between the height of the water in the boiler and the degree of superheat obtained from the superheater. Tests should be made on each boiler to determine the proper or best working height of water and then hold the water at this height. An example of such a test is given in Fig. 2.

Ideal water feeding is such that at all times the boiler is provided with sufficient water for safety and not enough to slop over into the steam main or superheater, thereby ruining a perfectly good turbine or engine.

What is still more important, proper feeding must be continuous (not the on again, off again variety) and the feed must bear a direct proportion to the change in load but not necessarily coincident with the load and at the same time the feeding must be such as to be a heat reservoir during a decreasing load for use during the increasing load.

Proper size of feed valve should always be installed, for it is possible to feed to a boiler at such a rate as to stop it from steaming.

The ideal method of getting results is to have the wheel of the regulating valve calibrated to show to the water tender, the horsepower capacity at various openings of the valve.

There is no question that the installation of a good automatic feed water regulator will accomplish just as good results as will be obtained from the use of the average water tender, and it is possible thereby to effect a saving of labor and uniform operation of the boilers.

Water and Steam Piping for Air Compressors

COOLING WATER for air compressor cylinder jackets, cylinder heads and intercoolers must always be turned on before the compressor is started. Sufficient water must be used to keep down the heat of compression. In case of stage compression the greatest efficiency is obtained by having the outlet water from the intercooler at a low temperature. The water supply to air cylinders and intercooler should be independent of each other and the flow controlled by a valve on the inlet.

Always use city water when possible and avoid using dirty water, as it clogs the water jacket and reduces the cooling efficiency. Do not forget to shut off the water when the compressor is stopped and also open all jacket drains in freezing weather. Outlet water should flow into open funnels allowing frequent temperature readings to be made, a rise in temperature indicating deficient cooling, carbonized discharge valves, or leaking piston rings.

Steam piping to air compressors should drain toward the compressor, for it is likely to contain low spots or pockets where water can accumulate, which would be carried into the steam cylinder and cause serious damage upon a sudden increase in air demand calling for a rapid flow of steam through the pipe. The use of a steam separator and trap is recommended if the compressor is located some distance from the boiler. Its use increases the safety and economy as a result of supplying drier steam.

Exhaust piping should be laid beneath the floor to the side of engine room, then vertically to the atmosphere. The pipe leading to the riser should pitch slightly toward it. The connection with the riser should be made to provide a drain for condensation. On compound steam cylinders the receiver must be drained. The drain should always be opened before the starting and steam turned into the receiver through a bypass valve. The receiver as well as the steam cylinders should be thoroughly warmed by steam before starting. If a condenser is used, the main exhaust pipe will be connected to it but there should also be an opening to the atmosphere provided with an automatic relief valve. A stop valve should be placed in the exhaust pipe between the condenser and relief valve. Exhaust piping should drain toward the condenser.

These notes appeared in Trade Standards prepared by the Compressed Air Society.

Combustion Control for Boilers*

FACTORS WHICH INFLUENCE CONTROL. STEAM FLOW, AIR FLOW AND FUEL FEED SHOULD FORM BASIS OF REGULATION. BY R. J. S. PIGOTT†

IN VIEW of the great diversity of method even today in applying automatic control to boilers, it seems that there is still a great deal of misunderstanding as to what combustion control really is. It would therefore not be out of place, perhaps, to go back to basic facts, and examine why it is we need any automatic control, and what functions we ought to control.

There are four distinct functions involved in the operation of a boiler:

(a) Supplying air in the proper proportion to burn the fuel. (b) Supplying fuel at a rate to maintain the required steam output. (c) Mixing the air and the fuel, and burning them at a suitable temperature to result in as complete combustion as possible. (d) Absorbing the generated heat into the boiler proper.

Air supply is based upon the chemical requirements of burning fuel, and is determined both by the amount of oxygen required per pound of fuel to burn it completely, and by the excess over this amount called for by the imper-

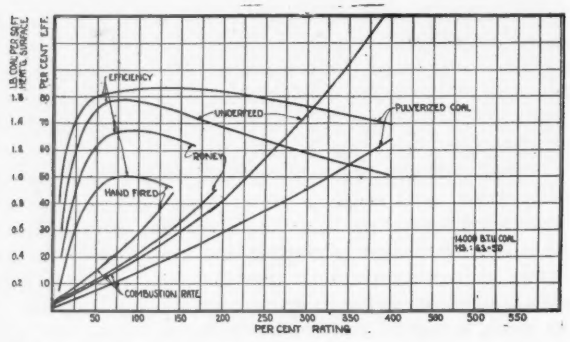


FIG. 1. OPERATING EFFICIENCY AND INPUT-OUTPUT CURVES FOR VARIOUS FIRING EQUIPMENTS

fect mixing provided by the fuel-burning device. It is a convenient fact that the air required per 10,000 B.t.u. of any commercial fuel, from lignite to oil, is 7.6 lb. within 2 per cent; but this is of no help to regulation, since the requirements of the fuel as fired vary from 6 to 14 lb., for reasonably complete combustion.

Excess air required is very largely determined by the firing equipment, and in a much smaller degree by the furnace. The hand-grate usually requires from 60 to 80 per cent excess air to get its best results under good operation; the older overfeed stokers, 55 to 65 per cent; the modern chain-grates, and the underfeed stokers, 40 to 55 per cent; powdered fuel burners, or oil burners, 15 to 25 per cent; surface combustion with gas, no excess air. These variations are almost wholly due to the differences in thoroughness of mixing the air and volatile combustible.

Once the fuel, the fuel-burning equipment and the furnace are chosen, the air-fuel ratio is largely fixed, and will remain so unless the character of the fuel, the temperature in the furnace or the mixing, is changed. This factor is one that can be automatically controlled, for the most part, and is the most important one affecting efficiency.

Regulation of fuel supply in accordance with output, the second function, constitutes the control for capacity, in order that the steam pressure should not fall too low to operate the connected prime-movers, or rise above the popping pressure of the safety valves. It is worth while at this point to break a lance on an old-established fetish of the boiler room, i.e., constant steam pressure. There is not, and there never has been, any direct relation between constant boiler pressure and efficiency.

It should be clear that regulation to constant pressure cannot give proper capacity regulation. There is only one way in which this function can be satisfied, and that is by quantity-measurement of coal into the furnace in some suitable relation to steam output. To satisfy the first function: i. e., proper proportioning of air and fuel, the air must also be simultaneously quantity-measured according to the same relation.

It is evident from a consideration of the input-output curve or the efficiency curve of any boiler, that the ratio of fuel to steam is not the same at different loads. Figure 1 shows these curves for various kinds of firing equipment, under normal conditions of installation, if one may use such a term in connection with modern boilers.

Although the amount of fuel and air to steam is not a constant ratio, it follows a fairly regular law, and it is certainly possible to provide automatic quantity regulation of fuel and air in proportion to steam output.

Mixing of air and fuel is largely determined in operation by the firing apparatus and the furnace. In a similar way, the last function, absorbing the heat into the boiler, is a function of design, and is not materially affected by regulation, except insofar as the latter may affect furnace temperature and excess air. For our purposes, it may be disregarded for the present.

POSSIBILITIES OF REGULATION

From the foregoing consideration of the factors involved in firing the boiler, it should be self-evident that, in order to get the best possible efficiency out of a boiler installation, the fuel must be fed into the furnace every instant, with exactly the amount of air per pound of fuel required to burn it fully in the firing apparatus provided; and for proper output, both fuel and air must be supplied every instant in proportion to steam output. To do this by hand requires simultaneous continuous observation of, say, seven indications—steam flow, steam pressure, CO_2, stoker or feeder speed, uptake draft, furnace draft, and air blast—as usually provided hitherto. In addition, the operator must also see that his stoker is kept in proper condition of fire. It needs no demonstration to prove that such a set of conditions cannot be physically met. Add to the foregoing the storage effect of coal on the stoker, masking any results of adjustments the operator may make, and the case is still more difficult. Lastly, add to the preceding the knowledge that static pressures in drafts and blast do not tell the

*Abstract of paper presented before Metropolitan Section of the A. S. M. E. on April 30.

†Mechanical Engineer in charge of design, Stevens & Wood, Inc.

operator what he needs to know, namely, quantity of air supplied, and it becomes a matter of surprise that the operating efficiencies of stoker plants are as near the test efficiencies as they are.

There is another, though smaller, advantage to be gained from automatic control, and that is also largely due to the fact that the regulator is functioning all the time. This advantage is the immediate adjustment of fires in case of sudden drop or increase in load.

Before we can either control by hand or automatic, however, we must accomplish at least three things fairly accurately. We must meter steam output, fuel, and air input. We have hitherto neglected to do this, as can readily be shown. We often measure steam output, usually by flow meter; but we have almost never attempted to measure rate-flow of fuel-input; but ordinarily we have either left this function to a guess by the operator, or have left it to a so-called regulator operated by blast-pressure. With regard to air, we have been deluding ourselves with the belief that static drafts on blast or uptake were measurements of flow; they generally are not. The uptake draft, if the furnace draft is kept constant, is a good measure of rate-flow of flue gases, provided also that the boiler passages are kept in the same state of cleanliness. Under all other conditions, it is of little value. But blast pressure for a stoker is never a reasonable measure of flow, since it may be altered from 50 per cent to 100 per cent by changes in the fuel bed, for any given flow.

Furnace draft is the only static pressure in which we are interested. This must be kept slightly negative, to avoid overheating stoker fronts and doors, or blowing out flame or powdered coal, but must be kept as near zero as practicable, to keep down setting infiltration.

Methods of Accomplishing Regulation

To establish automatic control, we must have the following functions performed:

(a) Meter steam flow. (b) Meter coal feed in proportion to steam. (c) Meter air in constant ratio to coal. (d) Keep furnace draft slightly negative. The first impulse must come from steam flow, since this is the primary variable to which we must adjust the others. The device may be either the elements of a flow meter, or pressure-drop due to friction (which is really a form of flow-meter).

It must be definitely recognized that the primary impulse must not, in any case, be a device aimed at holding constant pressure at the boiler outlet, or anywhere else, because this is setting up a system analogous to an isochronous governor on a turbine: we cannot govern to absolutely constant speed in a turbine without instability; we must permit a slight change in speed with load, in order to provide a stable governor. Similarly, we cannot produce stable equilibrium in any automatic regulator, without allowing a pressure change, with load.

The primary impulse from steam flow must actuate the fuel feed in proportion to this flow, and the device must so operate that a given change in steam flow produces a definite proportional change in fuel flow; in other words, the regulator must be compensated. We have fairly good means ready to hand for metering coal flow, if coal is reasonably evenly sized, and moisture fairly constant, the speed of stoker chain or ram crank-shaft is a sufficiently accurate measure of coal rate-flow, by volume. Or in the case of powdered fuel, if the moisture is fairly constant, and the powdered coal kept in about the same condition of aeration, the speed of feeder-screws is a satisfactory measure of fuel-rate.

Similarly air flow must be regulated either direct from the steam-flow, or from the coal-flow, and must be compensated likewise. We may measure the air flow by the draft loss across the boiler surface, which is the difference between uptake draft and furnace draft: this measures flue-gas, it is true, but since the ratio between flue gas and air is a constant, provided the coal-air ratio is not altered, it is practically as satisfactory as measuring air direct, and in some cases may be more convenient.

There are three ways these three operations may be interlinked:

(a) Steam flow actuates fuel flow, fuel flow actuates air flow. (b) Steam flow actuates air flow, air flow actuates fuel flow. (c) Steam flow actuates air and fuel flow simultaneously.

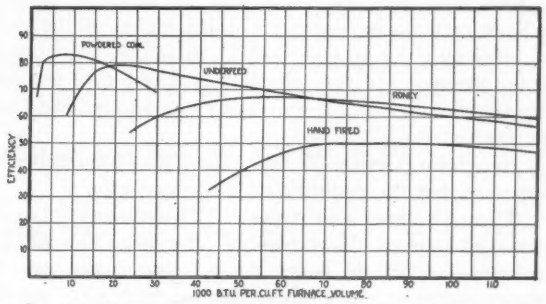


FIG. 2. OPERATING EFFICIENCY AND B.T.U. PER CU. FT. OF FURNACE

Requirements of Regulator Design

There are four characteristics which must be embodied in any successful automatic combustion control system. The regulator must be:

(a) Stable.
(b) Sensitive and speedy.
(c) Reliable.
(d) Powerful.

Stability depends upon elimination of counter-pressure regulation, and upon the character of the compensation. Sensitiveness (which must also include accuracy and speedy response) should be high, or else the regulation will not improve much over hand regulation. It must be reliable —as rugged and simple as may be—or it has no place in a power plant.

It has generally been the custom to buy such regulation as was available in uncorrelated units, and hang them around the plant, expecting them literally to perform a miracle. It is necessary that the power station designers consider automatic regulation as a part of the design, just the same as heat balance, and provide for application of the regulation system so that it is free to function, as a completely synchronized group of devices.

In operation, there are two major troubles that tend to destroy the performance of any regulating system: first, the general disbelief that any mechanical contraption can possibly regulate a fire as well as an experienced fireman; second, expecting the apparatus to do things without attention or supervision, that do not lie in its power.

Meter Types and Their Characteristics

Combustion Is Judged by Comparison of Excess Air Percentage in Flue Gases; Integrating Devices Need Improvement. By C. D. Zimmerman

METERS measuring turbine condensate, except those of the weir type, are usually subject to an inaccuracy due to the fluctuating discharge of the condensate pump which is usually present whether this pump is run on the throttle or the governor. In order to obtain an accurate measurement of the turbine water rate with any meter on the condensate, care must be taken to keep the condenser leakage below 1 per cent, which is usually accomplished by the aid of daily or weekly tests of the condensate.

The turbine water rate can be estimated from the average load, a vacuum and superheat with an accuracy of 1.0 to 1.5 per cent if the water rates are checked from time to time with weighing tanks. As the desirable accuracy is 1 per cent, the advisability of using meters on the steam or condensate for this purpose is, therefore, questionable, as the probable accuracy of either type is 3 to 8 per cent. Installations in which a weir meter can be used are possible exceptions.

Integrating devices for flow meters have been somewhat improved, but the majority are still unreliable.

There are three main types of CO_2 recorders or meters to measure the relative excess air—the steam flow air flow boiler meter, which shows the relative excess air; the duplex recorder, which shows the per cent CO_2 and the per cent combustible gases; and the ordinary CO_2 recorder.

The steam flow air flow boiler meter consists of a steam flow pen and an air flow pen which records the relative amount of gas flowing through the boiler and is actuated by the difference in draft between the superheater pass and boiler uptake. The air flow pen is set in such a way that it is parallel with the steam flow pen when the excess air is at the desired amount for which the meter was set. If the excess air is above the desired amount, the air flow pen rides above the steam flow pen and vice versa.

Advantages of this meter are that it also shows the steam output of the boiler and the relative amount of gas flowing through the boiler which is of use in checking the character of the banking operations as the dampers should be closed and the gas flow through the boiler at a minimum when the boiler is banked. An additional feature which appears to have great advantages (especially for underfeed stokers) is a record on the same chart of the stoker speed with a scale such that under normal conditions the record of stoker speed is two spaces below the air flow and steam flow records. An indication is obtained thereby of the diligence of the fireman and variations from the proper excess air can usually be traced to faulty stoker speed. The temperature of the flue gas is also usually placed on the chart with the advantage of having it on the same chart with the record of the boiler rating. There is no confusion due to having these four records on the same chart.

Two indicators showing the boiler rating and draft over the fire, are often placed on the same meter. Additional advantages are that the time lag is practically nothing, the records are based on the total gas, which is difficult to do on wide boilers with a CO_2 recorder, and less care has to be taken to keep the lines air tight and the gas clean. Gas flow through boilers is often in stratified streams of different CO_2 content and temperature due to uneven fires on the stoker. Gas samples and flue gas temperatures should, therefore, be an average of the total.

The duplex recorder gives on one chart the per cent CO_2 and per cent combustible gases. For the ordinary boiler set 3 to 10 ft. above the grate, there is a certain value of excess air for which the total losses are at a minimum and if the amount of excess air is decreased, the total losses are increased due to the increases in the ash pit loss and the loss due to incomplete combustion of the gases. The use of the duplex recorder shows the operators the type of fire which results in the highest per cent of CO_2 without combustible gases. Whether this type of fire results in the minimum total losses can be determined only by analysis of the coal and ash.

There are a number of successful CO_2 recorders, employing chemical processes. Several CO_2 recorders are now available which do not use chemical but which are electrically operated and a guarantee is made on their degree of accuracy and time lag.

Use of one CO_2 recorder with pipe connections to several boilers has proved unsatisfactory in cases which have come to the writer's attention. The chief disadvantages are that the time lag is large and due to the large number of valves and fittings and the long piping, it is extremely difficult, if not impossible, to keep air from leaking into the pipes.

Temperature Recorders

Poor results with temperature recorders have often been due to a poor understanding of this type of meter on the part of the purchaser. Recorders actuated by vapor tension are more sensitive than those actuated by gas pressure, but have had until recently the disadvantage of the unevenly spaced chart which is difficult to average. A recorder of this type with an evenly spaced chart is now offered. The maximum range of this type of recorder is 400 deg. F. Union sockets are more sensitive than separable sockets but have the disadvantage of being more difficult to change as it is often necessary to cut out of service long steam or water lines before the meter can be removed. Due attention should also be paid to the relation between the bulb size and the length of the capillary tubing as variations in the temperature of a long tube causes errors when it is used with a short bulb. The bulb length should be 60 to 70 per cent of the diameter or width of the area through which the medium measured flows. A bulb can often be made longer than the diameter of the pipe for which it is to be used if this is necessary by placing it in an elbow. As all recorders must be checked periodically by a standard thermometer, a thermometer well, as long or longer than the recorder bulb, should be inserted wherever possible near the recorder bulb.

Some companies are using a thermo-couple or a series of thermo-couples to measure flue gas temperature or check existing recorders, as difficulty is encountered where there is only a few feet between boilers in obtaining an accurate measurement of the average flue gas temperature across

the boiler uptake with thermometers of the ordinary indicating type.

Ten out of sixteen stations report the use of a temperature recorder for the exhaust steam from the main turbines. If this recorder is used only as a check on the operation and a high degree of accuracy is not essential, a bulb 6 to 8 in. long, placed almost anywhere in the exhaust chamber, is sufficient. If a high degree of accuracy is desired and especially if the exhaust temperature is to be used to determine the air leakage by comparing it with the absolute pressure in the condenser, great care must be taken in determining the size and location of the bulb. Due to the high velocity of the steam coming out of the turbine and the rotation of the wheels, the flow of steam is exceedingly uneven across the exhaust chamber and bulbs placed near the wheels are subject to an error due to the impact of the high velocity steam. For these reasons the bulb should be placed as far from the turbine wheels as possible—just above the condenser tubes is probably the best location. Due to the uneven flow, a large bulb 3 to 5 ft. long, or two bulbs joined to one capillary tube and placed about a quarter the distance from each end of the condenser, would probably be the best. As the flow of steam is from the turbine, through the exhaust chamber, and to the middle or bottom of the condenser, this bulb can be used only to detect air leaks above its location. An installation similar to that described above has been used to determine the air leakage with a large amount of success. The most reliable method and a method which shows the presence of an air leak in any part of the unit, is the Worthington system by which the air removed from the condenser is measured through an orifice.

A device has recently been developed by one of the manufacturers which protects thermometer recorders from rises in temperature beyond the desired range of the instrument. This is of particular value for temperature recorders used on turbine units.

Vacuum recorders, whether the scale is 0 to 30 or 20 to 30, are more inaccurate than the usual vacuum temperature recorders as a measurement of the vacuum and cannot be used for computations.

The use of pens suspended from the top of the instrument is becoming more common and has the advantage of being free from ink corrosion. The use of instrument boards is also becoming more common. Draft gages for operating purposes, using colored liquid as an indicator, have proved somewhat unsatisfactory due to leakage and evaporation of the liquid and clogging of the passages with dirt. Draft gages using bellows or submerged bells, are more satisfactory, the submerged bell type being the most accurate. For research and test work, the inclined draft gage or U tube is still the most reliable and accurate.

There are various methods, both electrical and chemical, for determining the concentration of condensate water. A recorder actuated by a thermo-couple has been used for this purpose but data on its reliability is not available. Another installation is an indicator which can be connected to any one of several thermo-couples.

A summary of a questionnaire sent to 16 stations ranging in capacity from 40,000 to 203,000 kw., shows the following: Practically all companies report the meters as satisfactory with one or two exceptions or reservations which have already been discussed.

Ten stations measure the water to groups of boilers by means of Venturi meters, two of which have Venturi meters on individual boilers. Two stations measure the water to groups of boilers by means of orifice or nozzle meters and four stations measure this water by means of weir meters.

Steam from each boiler is measured in every station but one.

Steam to the turbines is measured in nine stations. In four of these stations the condensate is also measured, two using orifice meters and two using Venturi meters for this purpose. In three stations the condensate only is measured, one using a weir meter, one an orifice meter and one a Venturi meter. Four stations do not measure either the steam or the condensate..

Two stations report the use of a blow down meter. Ten stations report the use of a steam flow air flow boiler meter as a guide to the fireman, and four of these also report the use of a CO_2 recorder on the same boiler. Three stations report the use of a CO_2 recorder alone, and one station reports the use of the duplex recorder. Several

NUMBER OF MEN REQUIRED FOR METER MAINTENANCE IN POWER PLANT

Station Capacity	Boilers Number	Boilers Size	Recorders Boilers	Recorders Turbines	Total	Meter Men	Recorders Per Man
40,000	4 4	1375 1456	42	10	52	2	26
45,000	6	1372	25	4	29	1	29
60,000	28	600	23	4	27	1 & 2 *	10-27
90,000	12	1500	27	17	44	1 & 3 *	10-44
60,000	8	1500	19	15	34	1 & 2 *	10-34
100,000	10 4	1262 1384	100	21	121	3	40
120,000	15	?	80	40	120	3	40
150,000	12	1890	24	12	36	1 *	36+
180,000	4	2365	20	20	40	4	10
258,000	77 4	686 3060	131	34	165	4	41

* Used on both, meter and test work.

makes of CO_2 recorders are reported as used. Two stations do not use any meter for this purpose.

Thermometer recorders of the gas filled or vapor tension type, are used almost universally on boiler and turbine units. One station reports the use of thermo-couples at each end of the superheater and two stations report the use of thermo-couples for flue gas temperatures.

The number of men used on meter work varied from one to four, and the period of checking meters varied from two weeks to six months, with the exception of CO_2 recorders, which are usually set daily. One large station checks its CO_2 recorders twice a day. One company operating three large stations reports that no men are used on meter maintenance and no definite schedule of meter inspection is used. In these stations each operating department takes care of its own meters. Although this system may be successful in some cases, it has failed in a large number of cases. The accompanying table gives an

indication of the number of men needed on meter maintenance work.

As the most important use is the determination of data from which the boiler efficiency can be calculated, this should be the first consideration. The meters necessary for this service are a meter to measure either the water to the boilers or the steam from the boilers, and temperature recorders for the water to the boilers and the steam from the boilers. In cases where the water blown down from the boilers is greater than 3 to 4 per cent of the total, a steam-flow meter is of more value than a water meter and the use of both is recommended wherever possible. Where no superheated steam is used, a thermometer recorder for the temperature of the steam is not always necessary to determine the boiler efficiency but is usually of great value in showing the character of the water feed and in improving this to what it should be by giving a record of the time and amount of "shots" of water from the boilers.

In the following outline are given the meters required for a typical installation. The meters for miscellaneous use are mainly of value where considerable planning work is done and results are followed in detail by the calculation of the performance by means of a heat balance or similar report.

INSTRUMENTS FOR BOILERS IN SMALL BOILER PLANTS AND POWER PLANTS:

Water to group or steam from each or both.

Excess air meter or CO_2 recorder.

Temperature recorder for water to group, steam and flue gas from each.

Indicating draft gages, for furnace, wind box, uptake.

ECONOMIZER INSTRUMENTS:

Temperature recorder for gas and water from economizer.

TURBINE INSTRUMENTS:

Weighing tanks for water rate tests or weir meter. Recording thermometer for steam to turbine, and condensate from turbine. Indicating thermometer for steam to turbine, water in and out of each condenser. Standard gage board.

MISCELLANEOUS INSTRUMENTS:

Flow meter for make-up. Recording thermometer for exhaust steam from each set of auxiliaries. Wattmeters to measure electric power to boiler room as separate from station use.

METER IMPROVEMENTS

Improvements in the reliability and accuracy of steam flow meters and integrating devices in general are greatly needed. Considerable improvement in the use of power plant instruments can also be made by the users themselves by taking greater precautions in installing the meters properly. When the fact is considered that the value of power plant instruments depends largely on the confidence placed in them by the operating men, it may be seen that no reasonable installation expense should be saved at a sacrifice of the future reliability of the instruments. This is particularly true of piping for flow meters which should be of such reliability and workmanship as to be as leak proof as possible.

Acknowledgment and thanks are due the operating companies to which the questionnaire was sent for their generous contributions to the subject matter of this article, also to several of the instrument manufacturers.

Recent Developments in Pipe Insulation

FOR HIGH TEMPERATURES SPECIAL INSULATION MAY BE USED NEXT TO THE PIPE WITH HIGH HEAT RESISTING MATERIAL AS AN OUTER COVER

STEAM PIPES must be insulated to prevent the flow of heat from the outside of the pipe to the surrounding air. There is no advantage in furnishing dry steam at the boiler if bare or improperly covered pipes deliver steam at the point where it is to be used at a great loss in temperature or in a wet condition. The fact of the matter is that each B.t.u. lost by radiation from a steam pipe represents about 1.4 B.t.u. which must be supplied from the coal pile, this being based upon a boiler efficiency of about 90 per cent.

Flow of heat from the liquid in a bare or insulated pipe to the outside surrounding air is measured by the number of heat units (B.t.u.) that flow through the walls of the pipe, or insulation, or both, and it is usually expressed in the number of B.t.u. that flow through an area of one square foot in one hour. This is the basis of most radiation curves and tables.

Rate of flow through a certain thickness and at a certain difference in temperature determines the conductivity of the material through which the heat flows. A smaller number of heat units flow through a material with low conductivity than one with high conductivity. The relative efficiencies of various insulating materials may be appreciated by comparing their conductivities under similar conditions. A material which would offer no resistance to the flow of heat may be said to have an insulation efficiency of zero and an insulation that would allow no flow of heat through it would be 100 per cent efficient.

Efficiency of an insulating material is expressed by a percentage which is the per cent saving which would be effected by insulating a pipe with that material over what would be lost if the pipe were left bare or uninsulated. The efficiency per cent is obtained by subtracting the heat loss of the insulated pipe from the heat loss of the uninsulated or bare pipe and dividing the difference by the heat loss from the bare pipe.

HIGHER TEMPERATURES ARE BEING USED

During the past few years there has been a tendency among engineers to use higher and higher steam temperatures. The reason for this is to raise the overall efficiency of the plant. The point has been proven and it has therefore become necessary to adapt power plant equipment to the new conditions. This has made it necessary to develop a pipe insulation which will withstand temperatures of 750 deg. F. and above.

It is a known fact that most insulating materials which were entirely satisfactory for temperatures of 500 to 600

deg. F. cannot be used economically or with satisfaction at temperatures much in excess of the higher figure. For example, 85 per cent magnesia is a highly efficient and satisfactory insulation for high pressure steam and low superheat conditions but, unfortunately, it is not entirely satisfactory for use on pipes at temperatures above 600 deg. F.

It is known that 85 per cent magnesia calcines seriously at temperatures above 600 deg. F. and at such temperatures the material is calcined to such a depth that serious disintegration takes place. The calcining effect is accomplished by a shrinkage in volume of about 15 per cent, which not only causes the material to crack but also opens up the joints and therefore causes considerable increase in heat loss.

Two Materials May Be Used

To meet the requirements of high steam temperatures some companies prepare a high temperature insulation which not only takes care of the present high steam temperatures but which is suitable also for temperatures up to 1200 deg. F. This not only assures adequate provision for the maximum steam temperatures used so far but it

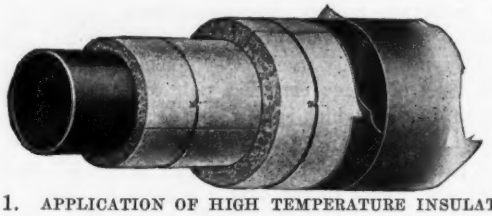


FIG. 1. APPLICATION OF HIGH TEMPERATURE INSULATION WITH OUTER COVERING AS PRACTICED BY JOHNS-MANVILLE

also takes care of higher ranges of temperature which may come into use with future developments. A practical method of overcoming the high temperature conditions efficiently and economically is, first, to insulate the pipe or hot surface with a high temperature insulation and then apply outside of this a layer of 85 per cent magnesia or other insulation, as illustrated in Fig. 1. In this construction advantage is taken of the higher efficiency of 85 per cent magnesia, or other insulation, at the lower temperatures, where its use is satisfactory.

High temperature insulation should have good insulating value and should be used in thicknesses sufficient to reduce the temperature to a point which will not affect the more efficient 85 per cent magnesia insulation, or other insulation, which is applied over it. High mechanical strength, good heat resistance, and extremely low shrinkage at high temperatures are required of a high temperature insulation.

This combination outlined above is superior to either material used alone and it results in an insulation which will withstand high temperatures without deterioration, as evidenced by shrinking and cracking and which has a high insulating value and high heat resistance.

In Fig. 2 is shown graphically the magnitude of heat losses from bare pipe and the saving that may be effected by proper insulation. The upper curve shows the heat loss from a bare pipe at various temperatures and the lower zigzag shows the loss from the same pipe if insulated with the proper materials for the different temperatures. The shaded portion between the upper and lower curves indicates the efficiency of the insulation. The letters opposite each of the lower lines refer to the legend in which is given a description of the proper insulation for that range of temperature.

As the temperature of the steam increases the cost of insulation usually increases; therefore, the insulations which are given on the chart show decreasing heat loss for the higher temperatures. The chart should be used to show the loss in B.t.u. per square foot per degree temperature difference per hour from uninsulated pipe and pipe insulated as shown in the legend. Due to the logarithmic scale to which it is plotted and the fact that it represents only one size of pipe, it is not practicable to take heat losses from it. Of course, the heat losses from different

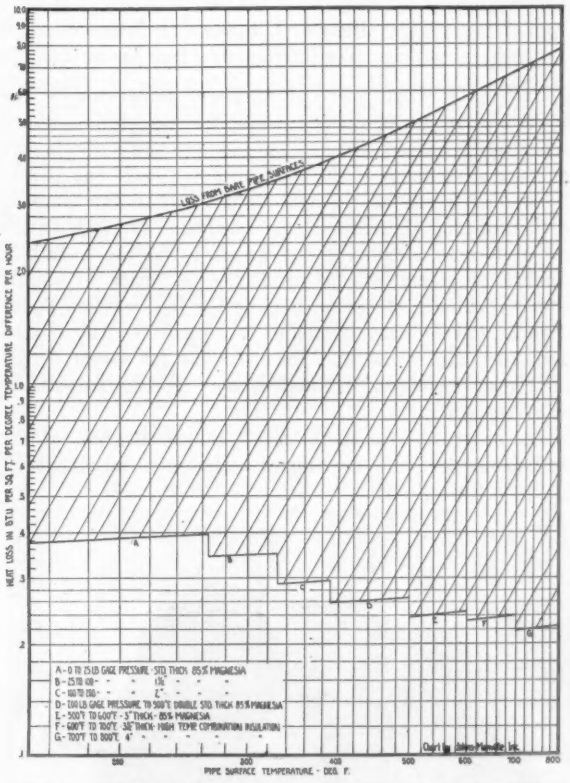
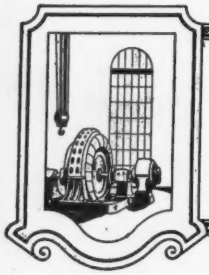

LOSS FROM BARE PIPE SURFACES
HEAT LOSS IN B.T.U. PER SQ. FT. PER DEGREE TEMPERATURE DIFFERENCE PER HOUR
PIPE SURFACE TEMPERATURE - DEG. F.
A - 0 TO 25 LB GAGE PRESSURE - STD. THICK 85% MAGNESIA
B - 25 TO 100 - " - 1½ " - " - "
C - 100 TO 200 - " - 2" " - " - "
D - 100 LB GAGE PRESSURE TO 300°F. DOUBLE STD. THICK 85% MAGNESIA
E - 300°F TO 600°F - 3" THICK - 85% MAGNESIA
F - 600°F TO 700°F. 3½" THICK - HIGH TEMP. COMBINATION INSULATION
G - 700°F TO 800°F. 4" " - " - " - "

FIG. 2. HEAT LOSSES FROM BARE AND INSULATED PIPE SURFACES

size pipes would be relatively the same but not numerically equal to those given on the chart.

As reported by the N. E. L. A., there has been produced what is termed the blue asbestos blanket or mattress, which is particularly desirable where frequent removal of insulation may be necessary. Trials made from this fiber show a good tensile strength. The specific volume of the material when fiberized is 25 per cent greater than the equal quality in white asbestos, weight for weight. Acids, alkali, sea-water and steam have no detrimental effects upon it.

These blankets or mats are constructed of two layers of 100 per cent pure blue asbestos cloth, filled with long, light, well-prepared, resilient, blue asbestos fiber and sewn around with 100 per cent pure blue asbestos sewing twine, stitched at close intervals to prevent the fiber from shifting. The thickness is regulated to suit the job. The mats are prepared in but few sections to facilitate easy and quick handling whenever an inspection of the objects so covered has to be undertaken at short notice.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Motor Applications in the Boiler Room

RECENT CHANGES IN METHODS OF CONTROLLING STATION HEAT BALANCE HAS RESULTED IN THE INCREASED USE OF MOTOR DRIVES. BY H. W. SMITH*

FOR THE DRIVING of auxiliary apparatus in the boiler rooms of our power stations, the electric motor has steadily gained favor. This is due not only to the inherent advantages of the electric motor itself but also to the change which has been brought about in the methods of maintaining the station heat balance. Previous to the use of bleeder steam, it was necessary to use a certain number of steam driven auxiliaries in order to supply sufficient exhaust steam for heating the feed water. Today however, low pressure steam for heating feed water is bled from the main units and the necessity for steam driven auxiliaries has been eliminated, and electric motors are being installed.

In order to discuss in detail the application of the electric motor to the driving of boiler room auxiliaries it

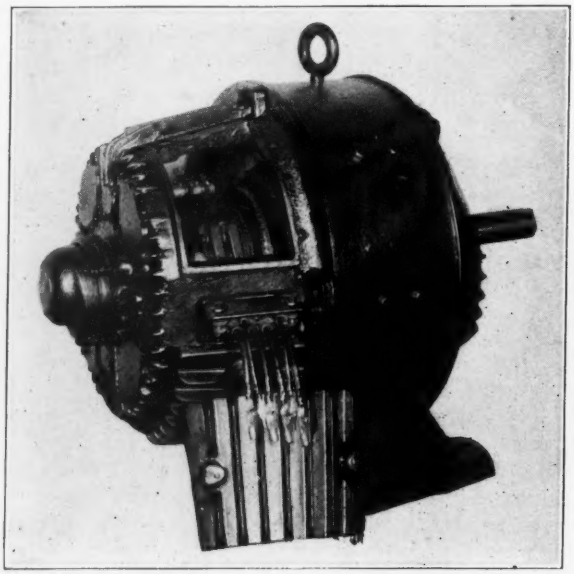


FIG. 1. A TOTALLY ENCLOSED MOTOR APPLICABLE TO STOKER DRIVES

is necessary to take up each type of apparatus separately and to study its service requirements. We shall, therefore, first take up the question of stoker and clinker grinder drives.

The essential requirements of underfeed stoker service are constant torque and wide speed range. The usual speed range being—four to one. The greater this ratio and the smaller the increments in speed adjustment the more satisfactory the stoker operation will be, provided the control system is not too complicated.

In order to simplify the electrical control, mechanical transmissions are sometimes used to obtain speed variation. In connection with constant speed, 2-speed or wound rotor induction motors, they sometimes supply all the speeds desired for clinker grinder or stoker control. There are two types mainly used. One consists of two parallel shafts, each of which carries a pair of cone faced spline mounted discs on which runs a special V-shaped belt. The two pairs of discs are operated by shifting levers, so that as one pair is separated, the other pair is brought together, causing the V-belt to run over a smaller diameter of one pair and a larger diameter of the other. This increases or decreases the speed ratio between the driving and the driven shaft. The other type is similar to the ordinary automobile transmission. Four speed ratios forward and one reverse are obtained by means of a gear shift and hand operated clutch. In combination with a wound rotor motor a speed range of 1 to 10.7 can be obtained.

D. C. Motors and Control for Stoker and Clinker Grinders

Where direct current is used the usual voltage is 230, although in a few cases 500 v. has been used. The types of construction used are either drip proof or totally enclosed. In most cases drip proof construction is sufficient to protect the motor. Solid covers are used over the upper end of each end bell and expanded metal over the lower half. The motors should have special insulation to protect the windings from conducting dust, which is liable to penetrate the windings and cause short circuits. Figure 1 shows a totally enclosed motor, while Fig. 2 shows installation of drip proof motors at Colfax Station, Duquesne Light Company.

The most satisfactory method of speed control is by shunt field control. Another method is by a combination of field and armature control. This method sometimes allows the use of a smaller motor but has low efficiency on the armature control points. The great objection, however, is the difficulty of determining the amount of resistance to use. When armature control is used, the speed varies with the load, so that it is necessary to predetermine accurately the required torque in order to obtain the correct speed. In a new installation, it is generally necessary to change the resistors after the stoker parts are worn in and require less power. Drum controllers are

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FIG. 2. INSTALLATION OF DRIP PROOF MOTORS AT COLFAX STATION

used, hand operated, but sometimes arranged to be driven by a chain from some form of regulator for automatic operation. About 16 speeds are generally given with a range from 300 to 1200 r.p.m.

For 60 cycle service, 2 and 3 phase 220-440-550 v. 2 speed wound rotor motors can be used. These motors operate as ordinary wound rotor motors reducing the speed from 1200 to 600 by insertion of resistance in the secondary. At this point the resistance is cut out and the winding pole is changed, connections being changed to correspond to 12-pole or 600 r.p.m. By insertion of resistance again the speed is varied from 600 to 6300 r.p.m.

Control equipment consists of a drum contactor controller with a pole changing and protective panel. Nineteen points for speed adjustment are provided. For push button control the controller is operated by a small pilot motor. The motors are of drip proof type with covers over the openings in the end bells away from the collector ring end, and hoods over the openings in the frame. Solid covers are provided over the collector rings and the two lower openings are left open. Motors are available rated at 30 hp., 15 hp., and 7½ hp. at the top speed of 1200 r.p.m. The use of a wound rotor motor has the same objection as armature control of d. c. motors, and it is generally necessary to change the resistance steps after the stoker is worn in to get correct speed increments.

2 and 4 Speed Squirrel Cage Motors

These motors are used in connection with mechanical variable speed transmissions. Pole changing is accomplished by a manually operated drum controller giving speeds of 1200 r.p.m. and 600 r.p.m. The motors are started by throwing them on the line in the 12-pole connection. A protective panel provides overload and low voltage protection if desired. Figure 3 shows the drip proof construction for squirrel cage motors.

Four speed squirrel cage motors are either with or without mechanical variable speed transmission. By pole changing speeds of 1800, 1200, 900 and 600 r.p.m. are obtained. The motors are started by throwing on the line on the 12-pole connection. Two separate windings are used on the stator and since at all times one of the windings is idle, the size of the motor is larger than a double winding machine to obtain the same horsepower rating.

Forced and Induced Draft Fans

In a fan, the discharge varies as the speed, the pressure as the square of the speed and the horsepower required as the cube of the speed. In selecting motor equipment, therefore, it is necessary to know accurately the fan characteristics. The operation of a boiler must not be endangered by the possibility of fan failure. Consequently, a certain amount of efficiency is often sacrificed to make the equipment as simple and dependable as possible. The motor and control equipment must operate for considerable periods without shutdown. Standard wound rotor induction and direct current motors have proved themselves thoroughly reliable for this service. Magnetic contactors and controller for power house application are required to carry only 50-80 per cent of the normal rating for industrial service.

Conditions under which the draft fan motor must operate depends on the location of the fan in the power house as well as on the speed cycle required of the fan. In most cases, the forced draft fan operates in a clean, cool place, and receives an ample volume of air for cooling. On the other hand, an induced draft fan must operate close to the boiler and stack when the temperature, particularly during the summer, reaches very high values. Where the ambient temperature is high the motor should be liberal in rating to prevent excessive insulation temperature.

A draft fan requires considerable speed variation in a large number of steps. In most cases a speed range of 2 to 1 will take care of the range through which modern boilers are operated, generally from 150 to 300 per cent of their so-called normal rating.

Wound Rotor Motors

Where the power supply is alternating current, it is recommended that wound rotor motor be used. Although

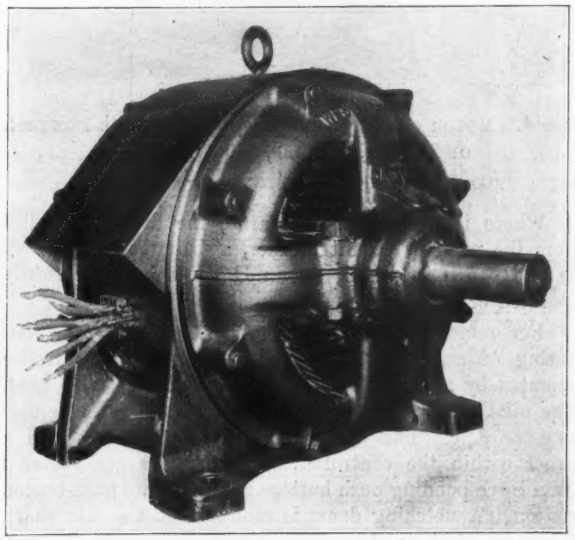


FIG. 3. VIEW SHOWING DRIP PROOF CONSTRUCTION FOR SQUIRREL CAGE MOTORS

the efficiency is decreased as the speed is reduced by inserting resistance in the rotor, the power required by the fan drops off so rapidly that the actual power loss is not serious.

For the control of wound rotor motors there is a variety of equipment available.

For hand control there are control equipments consisting of a slate panel, on which is mounted on oil circuit breaker for the primary circuit, electrically interlocked with a drum controller mounted in a horizontal position at the rear of the panel. The face plate and hand wheel of the controller are mounted on the panel and the whole is supported by substantial framework of iron pipe. Controllers must have from 9 to 13 points according to size and type.

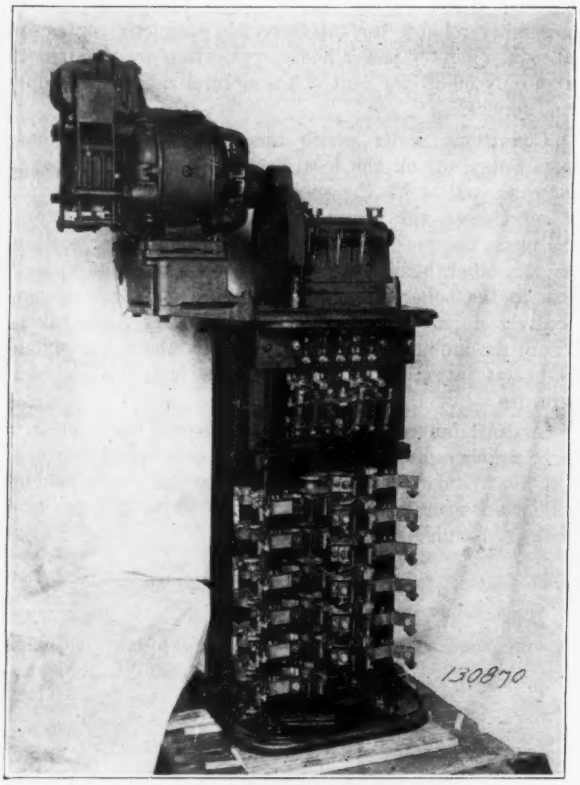


FIG. 4. MOTOR OPERATED DRUM CONTACTOR FOR CONTROL OF 200-HP., 3-PHASE, 2300-V. MOTOR

Where it is desired to separate the drum controller from the primary circuit breaker, a drum controller may be used with separately mounted contactor, electrically operated or hand operated circuit breaker.

For remote push button control, an equipment consisting of a motor operated drum contactor controller operated by means of a push button station can be used. The pilot motor is of the reversing type and can be either a. c. or d. c. Fast and slow relays are mounted on a panel within the controller. These relays are operated from corresponding push buttons at the remote push button station. A notching drum is mounted on the cam shaft. When the fast or slow push button is pressed the corresponding relay closes and operates the pilot motor to rotate the cam shaft and change the resistance in the motor secondary. When the push button is released the notching drum holds the relay circuit closed until the next running point has been reached. This makes is impossible for the controller to stop in a position midway between two operating points. A magnetic brake on the motor is released when the motor is operated and stops the motor quickly as soon as power supplied to the pilot motor is interrupted. This equipment gives 13 operating speeds with a range of 2 to 1. Figure 4 shows an equipment built for 200 hp., 3-phase, 2300 v., 60 cycle, 14-pole motor for the Commonwealth Edison Co.

Another type for remote operation is the magnetic contactor type operated by a master switch. This apparatus consists of a panel on which is mounted a primary contactor and a number of secondary contactors. The resistor is separately mounted. Control is from a remote master switch. When the master switch is moved to the first point, the primary contactor closes and the motor starts with all the resistance in the secondary circuit. The motor will then operate the fan at the lowest speed with all of the secondary resistance in circuit. As the master switch is moved further ahead, the secondary contactors close one at a time and short circuit sections of the secondary resistor which causes the motor to speed up. In this way a number of operating speed points are obtained. The motor is prevented from accelerating too rapidly by means of current accelerating relays. If the master switch is moved from the off position to the highest speed point the motor will accelerate gradually to the maximum speed. The accelerating relays will prevent each successive secondary contactor from closing until the current has decreased to a predetermined value. In the case of voltage failure, all contactors drop open and on return of voltage the motor is again accelerated automatically to its former speed. These controllers are designed from 5 to 7 speed points.

Another possibility is the use of a motor operated water rheostat for secondary control with an oil circuit breaker or contactor for the primary. This type of control gives an infinite number of steps of speed control with very few parts.

In some cases where it is advisable to work boilers through a large range, it is necessary to have a greater range of speed, perhaps 3 to 1. Instead of using one large motor for the whole range of speed, a saving is made by using two motors, the larger motor being connected to the shaft of the fan through a magnetic clutch. The attached curves, Figs. 5 and 6, show two examples showing the reduction in losses of the two motor equipment over the single motor.

During the past few years, some installations of polyphase brush shifting motors have been installed for driving forced and induced draft fans.

These motors have a stator like an ordinary induction motor with a rotor like a direct current motor except that the armature voltage is not over 80 to 90 v. Brushes on the commutator are connected to the secondary of a series transformer, the primary of which is in series with the stator. Variable speed is obtained by shifting the brushes on the commutator. This transformer lowers the voltage and increases the number of phases applied to the motor. In order to obtain the speed range for fans, it is necessary at some point to change the motor stator from delta to star, which requires automatically shifting the brushes to compensate for the change in speed.

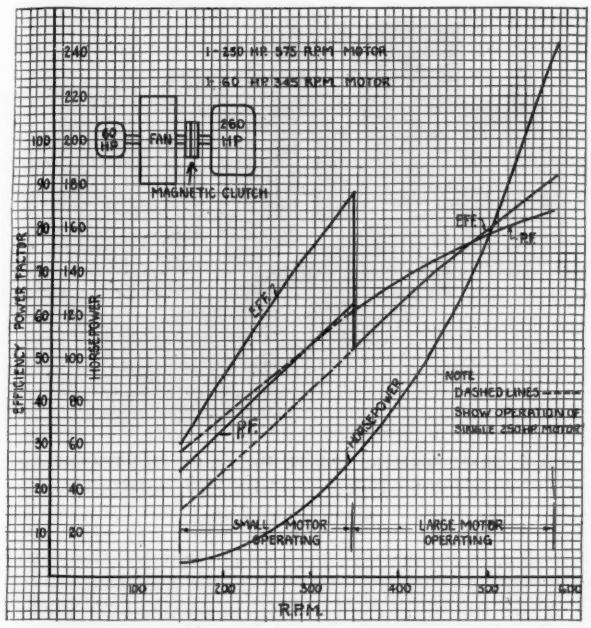


FIG. 5. USE OF TWO MOTORS FOR FAN DRIVES SHOWS GAIN IN EFFICIENCY

These motors have a good efficiency and can be obtained for a speed range of 3 to 1. The commutator and brushes are much larger than a d. c. machine and the first cost 75 per cent to 150 per cent greater. With a greatly increased maintenance for brushes and commutator it is doubtful whether they are better than the wound rotor induction motor or d. c. motor supplied from a motor generator set.

Where direct current is used 230 v. shunt wound motors are used with field control to give a 2 to 1 speed range. For control equipment two types are available.

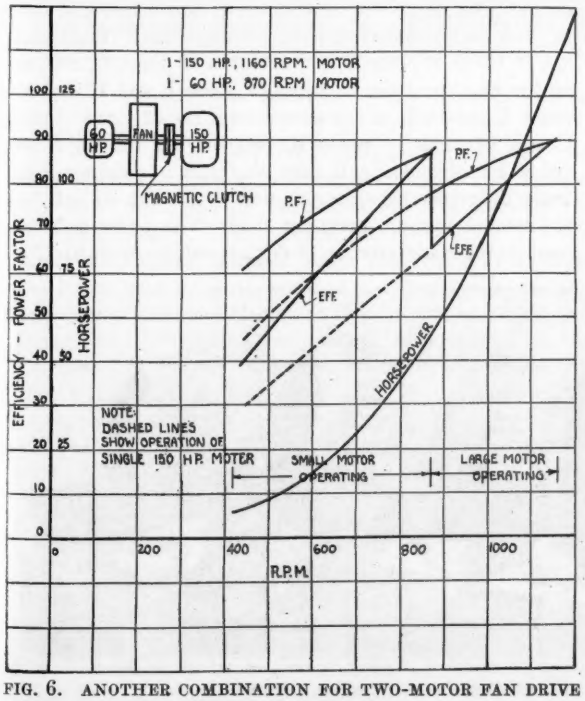


FIG. 6. ANOTHER COMBINATION FOR TWO-MOTOR FAN DRIVE

One consists of a slate panel on which are mounted two single pole carbon circuit breakers of the required size. The current breakers automatically trip and open the circuit on overload. Immediately in front of the panel and supported by the same framework is mounted a type "S" hand operated drum controller. This controller has several accelerating contacts which progressively short circuit portions of the armature resistor in starting. The motor stars with full field. When the last accelerating point is reached, the motor runs at the lowest operating speed. Moving the controller handle further cuts in field resistance step by step and increases the motor speed up to the maximum. The resistors are mounted in an angle iron framework directly behind the panel. The whole framework is enclosed by steel panels which protects the resistors from injury and reduce the hazard to operators.

The other type consists of a magnetic contactor type operated by a combined drum master switch and field rheostat.

The equipment comprises a number of shunt accelerating magnetic contactors, a multi-point accelerating relay, necessary starting resistance, one shunt line contactor with blow-out coil, a hand reset overload relay, and a double point knife switch. The drum master switch combine the master contacts, the field regulating points and field resistors, giving remote control as well as speed regulation from one point.

Boiler Feed Pumps

In most cases boiler feed pumps are driven by variable speed motors, though in some cases constant speed motors are used and the discharge is throttled.

There have been requests for 3600 r.p.m. wound rotor motors for driving boiler feed pumps. At the present time large 3600 r.p.m. wound rotor motors are considered to be an engineering risk requiring development and operating experience before they can be recommended for the severe duty in central stations. Synchronous or squirrel cage motors can, however be built, and at present 2-600 hp., 3600 r.p.m. squirrel cage motors are being constructed for the Commonwealth Edison Company for boiler feed pumps.

Coal Handling Equipment

Coal and ash conveying systems are generally in duplicate or have reserved capacity so that continuity of service is not so essential. Low voltage motors 440 v. or 220 v. are generally used for driving conveyors, though where coal tower or bridges are necessary the large amount of power often necessitates 2300 v. The general problems of application of motors and control to conveying systems do not differ at all from standard industrial application and need not be discussed in this article.

Individual electric plants are not widely used on farms in Great Britain but are found to a considerable extent on large country estates and are becoming increasingly popular for use in small country bungalows, according to reports from the Department of Commerce. As a rule, they could be arranged to furnish power for pumping or for other industrial purposes but in practice are rarely so used. They are probably most popular in Scotland, the American Consul at Glasgow estimating that there are from 6000 to 7000 in the whole of Scotland.

Transverter Makes Its Bow at Wembley

CONVERTS D. C. AT 100,000 V. TO A. C. AT 3000 V. WITH A SET OF REVOLVING BRUSHES AS THE ONLY MOVING MEMBER

TRANSVERTER is a name coined from the transformer and rotary converter, whose functions it combines, but the only moving part is a set of revolving brushes and the apparatus has little resemblance to either of its component parts. It had its origin in the effort to convert alternating current to high-voltage direct current, but is reversible and the set at Wembley is intended for converting from direct current to alternating. It can also be used, if so desired, for converting alternating current of any voltage and frequency into alternating current of any other voltage and frequency.

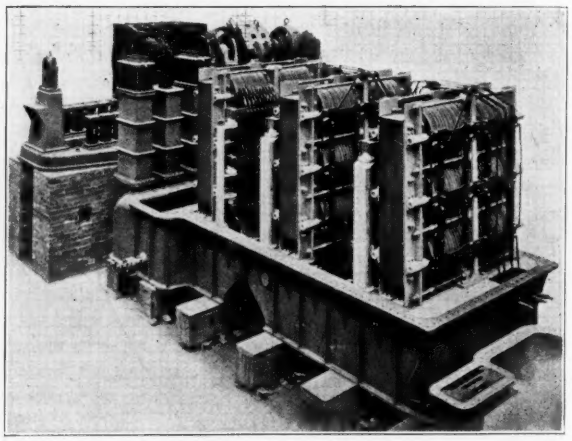


FIG. 1. TRANSFORMERS AND WINDINGS OF THE TRANSVERTER CASE REMOVED, WITH MOTOR AND COMMUTATOR DISKS AT THE REAR

PRINCIPLE OF ACTION

To get an idea of the method by which the transverter works, consider the action of a ring-wound armature in a two-pole field. Ordinarily, the armature is revolved in the field to generate electromotive force but the same result could be obtained by revolving the field about the armature. The brushes would, of course, have to revolve with the field to keep them at the proper point for commutation. Revolution of a field about the armature may be accomplished by actually moving a pair of field poles or by creating a revolving field by the use of three-phase alternating currents as is done in the case of induction motors and the latter is the method used in the transverter.

Having arrived at a set of stationary coils swept by a revolving field, we can cut the ring up into sections and place them in any arrangement most convenient, just so long as we keep them connected in the proper order, have them swept successively by a magnetic field and have them connected to a series of commutator bars over which a set of revolving brushes travels in synchronism with the motion of the magnetic field.

SOME ACTUAL DETAILS

All that the revolving field does to the windings of the ring-wound armature is to create a rising and falling magnetic field in the core of each armature coil. The same effect is produced on the secondary of a stationary transformer by the rise and fall of the current in the primary, so, if we arrange a series of three-phase transformers, having the secondaries connected in series and the primary currents producing a magnetic field of the same intensity in each transformer but with the magnetic cycles following successively at a slight phase difference, the e.m.f. resulting in the circuit made by the secondaries in series will be the same as that produced in the winding of the ring armature.

By having two secondary windings on each core and connecting them into two series in opposite relation, the effect of the two sides of the ring-wound armature is produced. The phase difference in primary magnetic fields is produced by using different combinations of windings from the three phases of the alternating current circuit. Thus, for three-phase transformer No. 1, use one coil of 30 turns of phase A for the primary winding on each core. For transformer No. 2, use 26 turns of phase A and 6 turns of phase C, reversed, on one core; use 26 turns of phase B and 6 turns of phase A, reversed, on the second core, use 26 turns of phase C and 6 turns of phase B, reversed, on the third core. For the third transformer, use 22 turns of phase A and 12 turns of phase C, reversed, on the first core; use 22 turns of phase B and 12 turns of phase A, reversed, on the second core; use 22 turns of phase C and 12 turns of phase B, reversed, on the third core. Other transformers will take windings to produce a like phase difference between magnetic cycles but all will have the same maximum magnetic field. The phase difference used in the transverter is 10 deg., the magnetomotive force

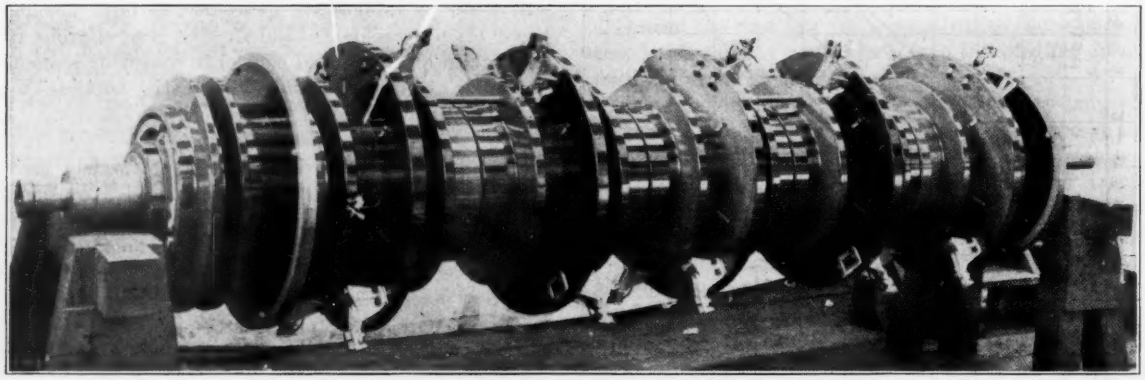


FIG. 2. TRANSVERTER BRUSH GEAR MOUNTED ON THE DRIVING SHAFT

of transformer No. 2 lagging 10 deg. behind that of No. 1 and that of No. 3 lagging 20 deg. behind No. 1, and so on.

Construction of Wembley Machine

In the first experimental machine built by the English Electric Co., Ltd., which was of 250 kw. capacity, six three-phase transformers were used but in the Wembley machine, which is of 2000 kw. capacity, three six-phase transformers are provided. These are oil cooled and have an oil reservoir on top of the case to take up expansion of the oil with change in temperature. Connections from the secondary coils are made to a series of ten disk-type commutators so as to give a wave winding connection as for a six-pole machine. Each commutator corresponds to one-tenth of a ring-wound armature, revolving in a six-pole field and there is no connection of the sections except through the brushes which are connected in series so that the terminal e.m.f. of the machine on the direct-current side is the sum of all the e.m.f.'s generated in the secondary coils.

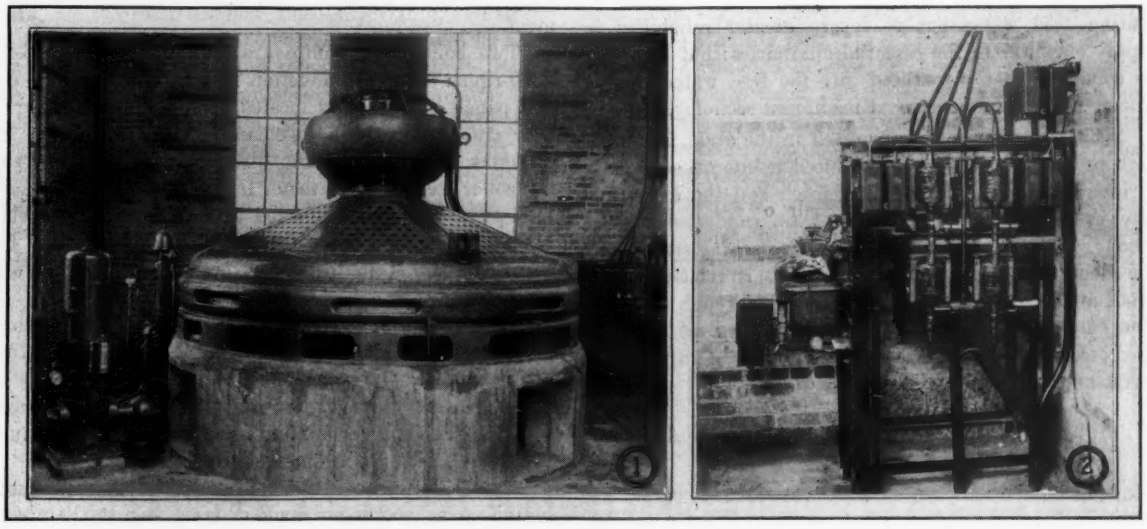


FIG. 1. GENERATOR TOGETHER WITH EXCITER AND GOVERNOR FIG. 2. THE AUTOMATIC LINE CIRCUIT BREAKER

All revolving brushes and brush gear are mounted on a shaft which is driven by a synchronous motor, taking current from one phase of the system which is connected to the transformers. This motor is excited by 110-volt direct current and is made larger than required to drive the brush gear so as to serve as a rotary condenser and help correct the power factor on the a.c. side of the system. It runs at 1000 r.p.m. to give 50 cycles per second on the a.c. side of the system. This a.c. side is designed to deliver 2000 kw. of three-phase current at 300 v., while the direct-current side is for 20 amp. at 100,000 v., transformation being made possible in either direction.

Length over all is 30 ft. 5 in. and width over the brush gear and motor is 17 ft. 10.5 in. While this seems large for a 2000-kw. machine, it must be remembered that, when handling current at such high voltages, it is necessary to allow considerable space for insulation.

Some idea of the appearance can be gained from Fig. 1, a view from the transformer end during erection and from Fig. 2, showing the brush gear and shaft, these views being taken from Engineering of London.

Hydro Station Receives Attention Once a Month

Automatic Features of Michigan Plant Make Small Water Power Developments Economical. By C. Shafer

AN AUTOMATICALLY controlled generating station has recently been placed in operation on the Portage River at Three Rivers, Mich., by the Michigan Gas & Electric Co. The plant operates without human attention except for a monthly visit when the governing time clock is wound, and at full load delivers 148 kw. to the line. This station is connected to a large transmission system and is used only as an auxiliary source of power, going on the line at 12 p. m. daily and cutting off at 5 a. m.

To the uninitated the plant has an almost uncanny system of operation. At a predetermined time the governing switch closes if the water is up, or comes up, and energizes a coil which opens a set of valves releasing the oil pressure on the central cylinder, or governor. The gates then open and bring the machine up to speed. A centrifugal speed device next comes into action and energizes a closing coil on the line current breaker, connecting the machine with the power line as an induction generator. The sequence of events is followed by the closing of a field switch which provides the generator with a direct current field, causing it to build up its own voltage. The gates of the turbine are now opened to a predetermined degree and the number of kilowatts to be produced is also predetermined.

In case of low water, failure of the governor oil pressure, over speed, under speed or hot bearings at any point the machine will instantly take itself off the line. It is impossible to put it on the line or keep it on as long as trouble exists.

With this plant it is possible to use the power afforded by a small stream without the prohibitive expense of human tenders. It has proved entirely successful and will be followed by several additional installations of a like nature in Michigan and Indiana.

Heat Balance at Hudson Avenue Station

SIX SOURCES OF HEAT ARE INVOLVED IN THE CYCLE. CONTROL IS AUTOMATIC. VERTICAL ISOLATION OF PHASES IS A FEATURE OF ELECTRICAL DESIGN

IN THE MAY 15 issue of Power Plant Engineering a summary of the more important features of the new Hudson Avenue Station of the Brooklyn Edison Co. was presented, including an outline of the cycle of operations involved in the heat balance system with a summary of the principal equipment concerned in the cycle. The present article aims to give more comprehensive information regarding this matter of heat balance, and to furnish further details on other salient points in the design of the station.

In determining the system of feed water heating for heat balance, two principles were dominant: (1) that by using bled steam from the main turbines the corresponding latent heat is conserved; (2) that overall thermal gain is secured by raising the boiler feed temperature to the maximum which can be had by use of bled steam. The house turbine was brought into the system not as a means of heating feed water but to insure greater reliability in supply of power to the essential auxiliaries; but being in, its condenser was introduced into the feed water heating scheme to secure its energy at maximum economy.

Six sources of heat are involved in the cycle, including high pressure and low pressure bleed points on each main turbine; the house turbine condenser; and the inter- and after-coolers for air ejectors on main condensers (when used). There is also the high pressure packing steam from the General Electric turbine; but this is relatively very small and reaches the system indirectly through the overflow tank. The accompanying tabulation gives principal predicted data for various points in the system at three-quarter loads.

PRINCIPAL PREDICTED RESULTS FOR HUDSON AVENUE STATION

Load on each main turbine..... 37,000 kw.
Load on house generator..... 1,760 kw.

	G. E. Unit No. 1	Westinghouse Unit No. 2
Total steam to turbine, lb. hr.....	415,700	409,600
Total steam bled, H. P. opening, lb. hr.....	47,600	45,200
Total steam bled, L. P. opening, lb. hr.....	22,000	17,400
Steam to house generator and to gland seals, lb. hr.....	33,500	
Vacuum, main condensers, in.....	29	29
Vacuum, house turbine condenser, in.	26	
Temperatures, deg. F.:		
From L. P. Heaters.....	190	177
From H. P. Heaters.....	292	277
Boiler efficiency, per cent.....	78.5	
Lb. steam, kw.-hr.*.....	11.34	
B.t.u., kw.-hr.*.....	15,380	
Lb. coal, kw.-hr.* (13,500 B.t.u. coal).....	1.139	
Thermal efficiency*, per cent.....	22.19	

Electric auxiliary drive, being an essential part of the heat balance system, is accomplished so far as possible by the 2300-v., 3-phase, 60-cycle system with three sources of supply, as outlined in our issue of May 15. Figure 1 shows the arrangement of this system as planned for the first four units. Control is exercised from truck switches on the machinery floor of the switch house, the steel cubicles being lined up against the wall, with trucks removable and terminal blocks accessible at the back of the cubicles. The forced draft fans, stoker drives, and clinker grinders, are run on 250-v. direct current with Ward-Leonard control, the motors being fed from boiler auxiliary power busses. The 440-v. system supplies the cranes in turbine room and switch house, and a number of smaller machines throughout the station, including revolving intake screens, capstans, locomotive crane, hotwell and vacuum pumps, elevators, and miscellaneous power equipment.

Two boiler feed pumps are driven by G. E. 625-hp., 1800-r.p.m. slip ring induction motors, with separate control panels conveniently located. Excess pressure regulators are of Ruggles-Klingemann type with double diaphragms, to hold constant differential pressure between the boiler feed and feed meter lines. The remaining boiler feed pump is direct connected to a 565-hp. Terry turbine for operation at 1750 r.p.m., 263 lb. pressure, 200 deg. superheat and 1 lb. back pressure, with a Terry-Foster regulator.

Each coal tower is equipped with a three-unit motor-generator set, the main hoist motors being 625 hp., 275-v., direct current, 180 r.p.m., and the trolley motors 75 hp., 250-v., direct current, 485 r.p.m., with Ward-Leonard control. The smaller auxiliaries in the towers are run on the 440-v., alternating current, circuit.

Control of the heat balance system is entirely automatic, but adequate records are made of every step in the process, by means of recording instruments. The knowledge thus made available will be utilized through daily analysis of heat balance and economic results. The instruments for these records are mounted on a board in the boiler control room, not for the purpose of supervision or control from this point but because it is a convenient place and the records of flue gas temperatures will prove serviceable to the boiler control operator. The instruments on the heat balance board are:

First row: 2 feed water pressure recorders showing pressure on the respective pairs of heaters. 1 recorder on pressure in air duct. 1 vacuum recorder for house turbine condenser.

Second row: Temperature recorders: Two 4-point, giving respectively for each main condenser the circulating water inlet and outlet, the hotwell, and the make-up temperatures. One 8-point, giving the flue gas temperature for each boiler. One 4-point, giving steam temperature at throttle and in header for each main unit.

Third row: Four 4-point temperature recorders, giving respectively for each of the four closed heaters the temperatures of bleed steam, of condensate, and of feed water at inlet and outlet.

*The rates given are based on gross kw-hr. generated, no deductions being made for station service and losses.

Fourth row: 4 recorders, showing respectively steam pressure on each bleed line from main turbines. One 4-point recorder for house turbine condenser, giving air ejector circulating water temperatures from each of the two units, temperature of circulating water leaving condenser, and temperature of the house turbine condenser condensate.

Boiler room or combustion control is centralized in the boiler control room, located at the west end of north side of the present boiler house. One control panel will eventually be installed for each group, with a master control panel for the complete installation in the center. The equipment of the first panel includes a load indicator, giving the momentary load on the whole group; a two-pen steam pressure recorder; an air duct pressure gage; four forced draft fan ammeters with button control for speed regulation individually; a group stoker speed indicator; buttons for group control and emergency control of forced draft fans and stokers; and transfer switches for automatic regulation of forced draft generator fields.

For the operator on the boiler room floor, individual control panels are provided on each boiler, having two flow meters, one recording air flow, flue temperature, and steam flow from one side of boiler, while the other records total steam flow, stoker speed, and steam temperature. Below these are gages showing superheater outlet pressure and pressure in the boiler drum, and a Foxboro draft gage giving wind box, furnace, and differential drafts. At the lowest level are placed the individual stoker and clinker grinder controls. In addition, one boiler in each row carries an air duct pressure recorder.

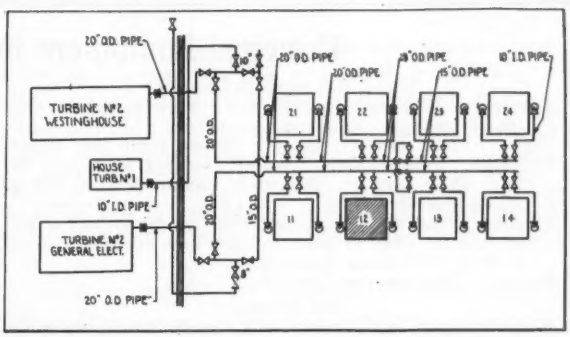


FIG. 2. HIGH PRESSURE STEAM LINES FOR ONE GROUP

Similar thoroughness is manifested in the equipment of panel boards for the individual turbines, on which are mounted synchronizing lamps, synchroscopes, load indicators, frequency meters and signal apparatus, in addition to a very complete quota of vacuum and pressure gages.

Group arrangement is maintained throughout, so that each group may be operated as a practically independent unit. This feature is illustrated by the diagrams of steam mains shown in Fig. 2.

Figure 3 shows a diagram of present main generator and feeder connections. The vertical isolated phase construction of main circuit breakers built in cubicles without any brickwork compartments whatever greatly facilitated the work of installation. Operating from the mechanism above, any switch may be lowered to the disconnect position and tried out or examined; or, it may be lowered further

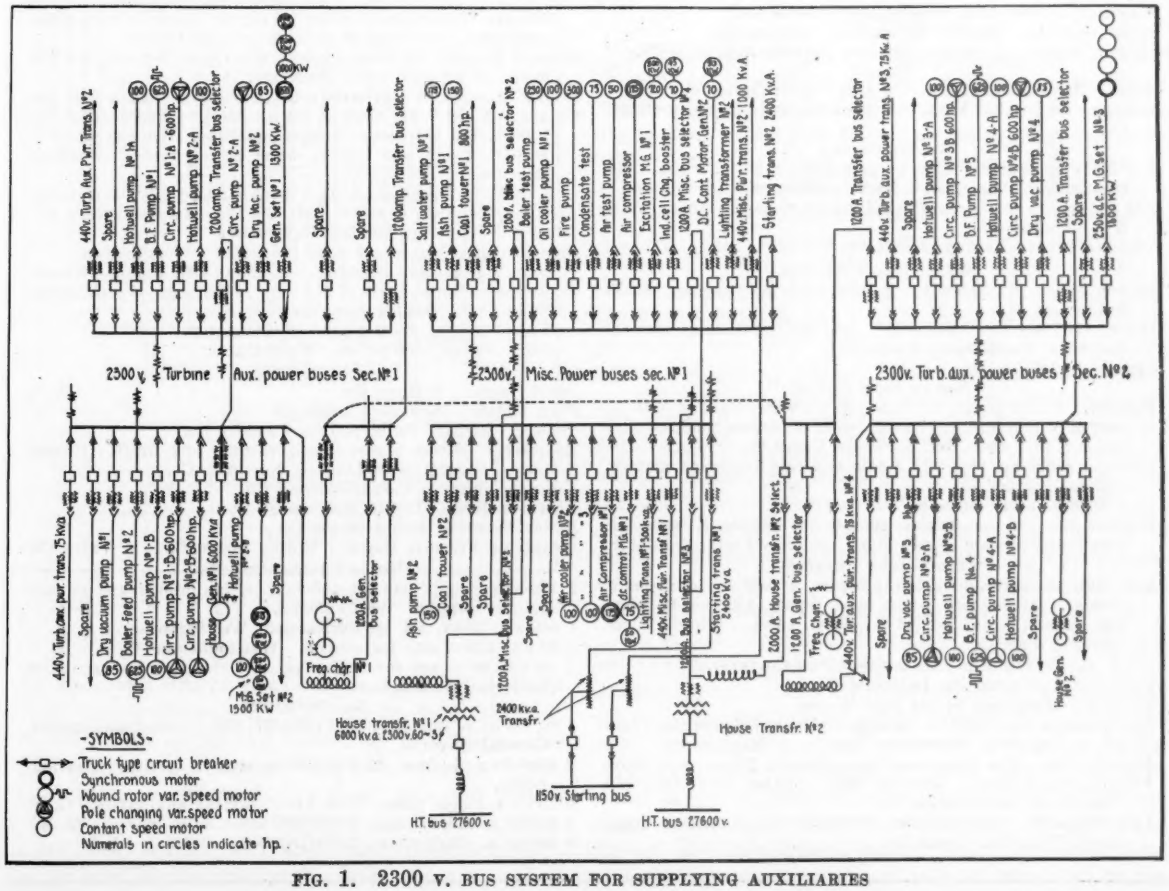

2300 v. Turbine Aux. power buses Sec. N°1
2300v. Misc. Power buses sec. N°1
2300v. Turb. aux. power buses Sec. N°2
House transfr. N°1 6800 kv.a. 2300v. 60~ 3ϕ
2400 kv.a. Transfr.
House Transfr. N°2
1150v. Starting bus
H.T. bus 27600 v.
H.T. bus 27600 v.
-SYMBOLS-
Truck type circuit breaker
Synchronous motor
Wound rotor var. speed motor
Pole changing var. speed motor
Contant speed motor
Numerals in circles indicate hp.

FIG. 1. 2300 V. BUS SYSTEM FOR SUPPLYING AUXILIARIES

Principal Equipment in Hudson Avenue Station

Coal Handling Equipment

Towers: 2 250-T./hr. Mead-Morrison. Traveling towers with duplex single roll crushers.
Cars: 10 5-T. electric (trolley). Bergen Point Iron Works.
Weighing: Fairbanks track scale. Installed by Bergen Pt. Iron Wks. Larries: End, 15-T.; center, 25-T. Traveling. Maine Electric Co.
Bunkers: End, 4000-T.; center, 6700-T. Waterproofed and brick lined. Gates at intervals above each firing aisle. Steel work by McClintock Marshall Co.
Storage: Main yard at Rossville, S. I.

Ash Handling

Sluice System: C. I., brick lined. Treadwell Engineering Co.
Crane: Locomotive crane, 5-cu. yd. bucket. Brownhoist.

Boilers and Superheaters

Boilers: 8 B. & W. cross-drum, 42 tubes wide, 20 high, superheater above 6th row. 19,650 sq. ft. heating surface.
Superheaters: 8 B. & W., single loop, 2 rows 2-in. tubes, 2508 sq. ft. superheating surface.
Soot Blowers: 22 per boiler. Diamond Power Specialty Co.
Feed Water Regulators: 16 4-in. Copes regulators. Northern Equipment Co.
Water Columns: Reliance Gauge Column Co.

Stokers

Underfeed, extension grate: 6 14-retort, Westinghouse Electric Co. New Frederick: 2 14-retort, Combustion Engineering Co.
Stoker Drive: Westinghouse d. c. motors, 300-1200 r.p.m., Ward-Leonard control.
Clinker Grinders: Furnished by stoker mfrs., double roll with Westinghouse type, single roll with New Frederick
Coal: Eastern Bituminous, averaging 13,500 B.t.u., 74 per cent fixed carbon, 16 per cent volatile matter, 8 per cent ash, 2 per cent moisture, 2 per cent sulphur.

Furnaces

Approximate volume, combustion space, 7500 cu. ft.
Boiler Settings: Rust Engineering Co.
Insulating Brick: Sil-o-cel.
Firebrick: Olive Hill, General Refractories Co.
Boiler Casings: Shevlin Engineering Corporation.
Hollow Walls: Air cooled, Bernitz Furnace Appliance Co.

Stacks

Steel: Height, 350 ft. above grates. Riter-Conley Co.
Lining: 4-in. radial brick. Alphons Custodis Chimney Const. Co.

Water Supply

For Make-up Water: City water supply, 2 20-in. mains. No treatment. Deaerated in main condensers.
For Generator Air Cooling: 2 artesian wells. Artesian Well & Equipment Co.
Water Meters: Neptune Meter Co.

Forced Draft System

Blower Fans: 4 170,000 cu. ft./min. at 7 in. pressure. B. F. Sturtevant Co.
Drive: 300 hp. direct connected, d. c. motors, General Electric Co., with Ward-Leonard control.
Speed: 600-667 r.p.m.

Boiler Feed Pumps

Pumps: 3 1500 g.p.m. for 210 deg. F. water against 400 lb. discharge pressure and 12 ft. positive suction head, normal speed 1750 r.p.m. Buffalo Steam Pump Co.
Drives: 2 625-hp. type "I" 4-pole slip ring induction motors, General Electric Co.
1 565-hp. Terry turbine.
Regulation: Motor driven pumps by Ruggles-Klingemann regulators. Steam driven pump by Terry-Foster regulator.

Feed Water Heaters

4, 2 high pressure and 2 low pressure, a pair for each main turbine. All heaters U-tube type, 4-pass, 3500 sq. ft. heating surface, ¾-in. No. 16 B. W. G. tubes. Wheeler Condenser & Eng. Co.

Piping and Valves, and Pipe Coverings

Piping: High pressure, Ballwood Co.
Exhaust: American Spiral Pipe Works.
Low pressure cond. suction castings: Fuller-Leheigh Co. (Liners to tunnels.) Weatherly Foundry & Machine Co.
Pipe Joints: Van Stone, on high pressure 2½-in. and above
Fittings, Cast Steel: Reading Steel Casting Co.; American Foundry & Construction Co.
Low Pressure: Amalgamated Products Co.; Kutztown Foundry & Mch. Co.; Crane Co.

Valves: Type or Use	Maker
Globe	Edward Valve & Mfg. Co.; Lukenheimer; Schutte & Koerting.
Gate	Chapman Valve Co.
Pop Safety	Consolidated Safety Valve Co.
Stop and Check	Edward Valve & Mfg. Co.
High Pressure C. S.	Edward Valve & Mfg. Co.; Chapman Valve Co.
Atmospheric Relief	Edward Valve & Mfg. Co.
Blowoff	Schiller Nolan
Float	Kieley & Mueller; Schutte & Koerting; Wheeler Eng. Co.
Bleeder and Chronometer	Schutte & Koerting.
Heater Relief	William E. Williams Valve Corp.

Prime Movers

Main Units: 1 General Electric turbine, single cylinder, 50,000 kw., 80 per cent P. F., to operate at 1200 r.p.m., 265-lb. gage pressure at throttle, 200 deg. F. superheat, and 1 in. back pressure. Driving 62,500-kv.a. generator, 13,800-v., 3-phase, 60-cycle, star-connected with grounded neutral.
1 Westinghouse turbine, compound, single shaft, capacity and operating conditions same as for G. E. machine.
House Turbine: 1 4500-kw., Westinghouse, operating at 3600 r.p.m., 265-lb. gage, 200 deg. F. superheat, 25 in. vacuum, 75 per cent P. F., 6000-kv.a. generator, 2300-v., 3-phase, 60-cycle.

Generator Air Cooling

General Electric Turbine: General Electric Cooler, 8 sections.
Westinghouse Turbine: Griscom-Russell V-fin.

Auxiliaries

Condensers: 2 70,000 sq. ft. surface, Westinghouse, radial flow, 2-pass, 13,368 1-in. tubes No. 16, B. W. G., 20 ft. long.
1 4000 sq. ft. Westinghouse 4-pass surface, 1490 ¾-in. tubes
Circulating Pumps: 4 51,665 g.p.m., Westinghouse, bottom suction, side discharge, 2 impellers, 600-hp. motor. 2 for each main condenser. 291 r.p.m.
Vacuum Pumps: 2 Westinghouse Le Blanc, 690 r.p.m., 1665 g.p.m., hurling water. 1 for each main condenser.
2 banks Westinghouse steam jet air pumps, 1 for each main condenser, consisting of 2 steam jet air ejectors.
Hotwell Pumps: 4 Westinghouse, 870 r.p.m., 2-stage, 900,000 lb./hr., 2 for each main condenser.
Intake Screens: 4 (ultimately 10), traveling. Chain Belt Co.
Cranes: 2 150-T. for turbine room. Morgan Engineering Co.
1 60-T. for frequency changer building. Whiting Corp.
1 10-T., 2 5-T. and 1 25-T. crane, screen house. Northern Eng. Co.
1 35-T. for machinery floor, switch house. Whiting Corp.
Air Compressors: 2 560 C.F.M., 2-stage. Ingersoll-Rand Co.

Special Equipment

Pumps: City Water: 2 2-in, 100 g.p.m. Worthington.
Salt Water (Ash Sluicing): 2 12-in. 5000 g.p.m. Worthington. (House Service): 1 8-in. 1500 g.p.m. Worthington.
Sump: 3. Goulds Mfg. Co.
Fire: 1 6-in., 1500 g.p.m. Worthington.
Oil: 3 6-in. 1500 g.p.m. Worthington.

Instruments

Draft Gages: Foxboro Co
Flow Meters: General Electric Co.
Venturi Meters: Builders Iron Foundry Co.
Recorders: Steam pressure and vacuum and draft. Bristol Co. Temperature: Leeds & Northrup Co.
V-Notch Meters: Yarnall-Waring Co.
Thermometers: Taylor Instrument Cos.
Boiler Meters: Bailey Meter Co.
Indicating Pressure Gages: Crosby Steam Gage & Valve Co.

Motor-Generator Sets

2 1300-kw. 4-unit sets for 250-v., d. c. fan, stoker and clinker grinder supply. Westinghouse.
1 500-kw. 250-v. set for excitation. Westinghouse .
2 50-kw. 125-v. sets for control. Westinghouse.
1 45-kw. 90-v. set for individual cell charging on excitation battery. Westinghouse.

Transformers

7 20,834-kv.a. single-phase, 13,800/27, 600-v. auto-transformers. General Electric.
2 6000-kv.a. 3-phase, 27,600/2300-v. station service. Westinghouse.
6 25-kv.a. single phase, 2300/440-v. turbine auxiliaries. G. E.
6 333-kv.a. single-phase, 2300/220/440-v. misc. power. G. E.
6 100-kv.a. single-phase, 2300/120/240-v. lighting G. E.

and removed. Normal operation of circuit breakers is from the main control room; but they may also be operated from the mechanism floor, interlocks being provided so that control can be exercised from only one point at a time. There is also an interlock which renders the tripping and closing solenoids inoperative while the raising and lowering mechanism is operative, and vice versa.

Individual generator and feeder control benchboards and panels are arranged in an oval in the main control room on the seventh floor of the switch house. With the operator's desk in the center and a very carefully planned lighting scheme, this makes an ideal arrangement.

Extraordinarily good provision is made for testing the high tension circuits. Ground and test switches on the main floor of the switch houses are connected for testing all 27,600-v. generator and feeder lines. These switches are connected by a test bus to a the main test room, where a 200,000-v. kenotron test set is located. Here also is a complete equipment of indicating and graphic recording instruments, so that comprehensive records may be had.

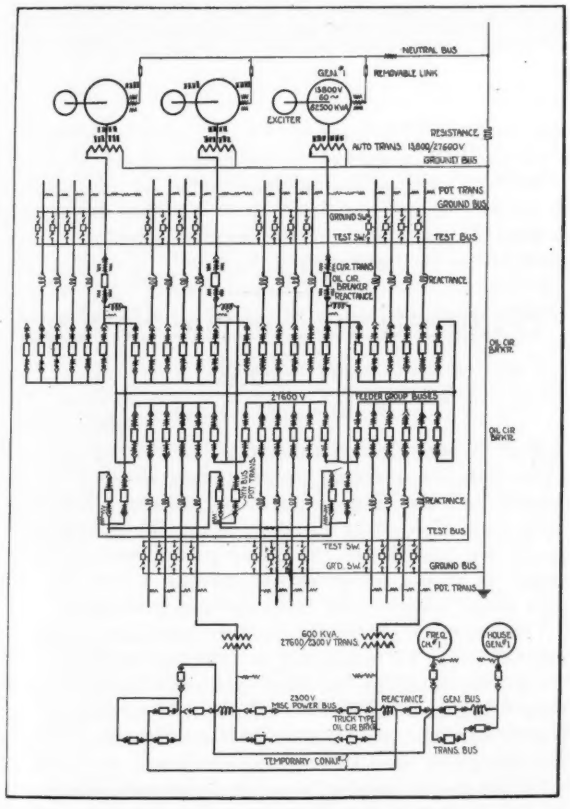


FIG. 3. MAIN GENERATOR AND FEEDER CONNECTIONS FOR PRESENT INSTALLATION

On the north side of ground floor of the switch house are the autotransformers for stepping up from 13,800-v. to 27,600-v. Above this is a ventilating floor, with house service transformer, rheostat, and pole changer rooms. Next over this is the machinery floor, Anderson switchboards, 440-v. power board, 2300-v. truck switches, 6000-kv.a. frequency changer, and M.-G. sets. There is a 35-T. crane for handling material on this floor. On a mezzanine are located more 2300-v. truck switches and auxiliary control room, and lighting board; also high and low tension meter test rooms. On the south side, ground and test switches for feeders are on the lower floor. C, B, and A phases of main circuit breakers occupy the three succeeding levels, with operating mechanisms for these breakers on the fifth floor. Returning to the north side of the building, the sixth floor is devoted to toilets, locker rooms, and battery rooms, with the H. T. control room on the seventh floor.

Elaborate facilities for communication throughout the station are provided by telephone, signal, and call systems. Of special interest is the station totalizing wattmeter, with remotely controlled indicators so that the operators in the boiler room, in the boiler control room and at the boiler feed pumps, as well as the chief engineer's office and the H. T. control room, are kept informed on this essential.

Design and construction of the station were supervised by an engineering committee composed of G. L. Knight, Mechanical Engineer, J. C. Parker, Electrical Engineer, and B. Houghton, Operating Superintendent, of the Brooklyn Edison Co., Inc., with assistants, and representatives of the consulting firm of Thomas E. Murray, Inc.

In closing, we wish to make acknowledgment to the officers and engineers of the company, through whose permission and co-operation the preparation of these articles has been possible.

Effect of Compressor Valve Design

PERHAPS NO other one thing had so much to do with the development of the present day compressor as the increasing tendency toward motor drive. The speeds in vogue prior to the past 10 yr., necessarily imposed by the type of air valve then in use, greatly handicapped the expansion of the motor driven machines, since the cost of the slow speed direct connected motor was almost prohibitive. This problem led compressor manufacturers to develop the light automatic valves of today, which permitted rotative speeds to be greatly increased, thus allowing the use of synchronous direct connected motors of comparatively low first cost. The present day moderately priced and efficient motor driven compressor is the result.

While present day speeds are almost entirely responsible for the great success of motor drive for compressors, these speeds have also done much for steam driven machines. Heretofore, steam driven compressors had been operated at considerably slower speeds than corresponding steam engines, due to the restriction imposed by the air valve. With this latter restriction removed, the increased speed has resulted in steam economies which have appreciably reduced the cost of compressing air.

It will be appreciated that there is absolutely no reason why a compressor should not be operated at speeds comparable with conservative steam engine practice, provided, of course, that air valves suitable for such speeds are employed. The light automatic air valves in use today have fully demonstrated their efficiency and durability at speeds greatly in excess of those used in standard steam engines, from which it will be seen that instead of the air valve development lagging, as in the earlier years of compressor development, it is now, according to the Compressed Air Society, leading by a considerable margin.

Rebuilding Boilers to Increase Capacity

REBUILDING a water-tube boiler in the power plant is not the simplest thing in the world, yet under the supervision of somebody who is familiar with the details of boiler erection, work of this kind can be accomplished without any unusual difficulty. A job of this kind was recently completed in the boiler room of the local public service company at Jefferson City, Mo.

Previous to making the changes, the boiler room at this plant contained four Babcock and Wilcox longitudinal drum boilers, 9 tubes high and 14 sections wide. These boilers supplied steam to a number of engines and turbines in the engine room. A new turbine was added some time ago and this, together with other increases in the load on the plant, necessitated the installation of more boiler capacity. The four boilers installed in the plant were relatively new and in good condition so it was decided to rebuild them, increasing the heating surface.

This was accomplished by dismantling two boilers at a time, the load being carried on two units while the other two were being rebuilt.

After two of the units were entirely dismantled, new supporting steel work was erected to accommodate the greater height of the rebuilt boilers. Simultaneously with the erection of the new steel work, a short length of new header, just long enough to accommodate three extra tubes, was attached to each of the old headers at the front and rear of each section by means of a nipple. The details of this work are shown in the photograph, Fig. 1. This shows one of the rebuilt sections ready to be hoisted in place. The new lengths of header and nipples were furnished by the Babcock and Wilcox Co., the makers of the boilers.

The rebuilt sections were hoisted in place and connected to the drums by nipples at the front and by new circulating tubes at the rear. Figure 2 shows one of the sections being secured in place.. The rear cross boxes of the boilers were not renewed.

As the boilers were 14 sections in width, and as three

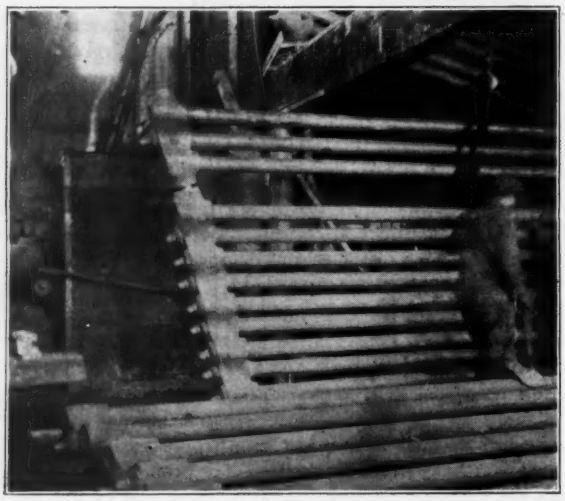


FIG. 1. A REBUILT SECTION READY TO BE HOISTED IN PLACE. NOTE THE SHORT LENGTH OF NEW HEADER

FIG. 2. ONE OF THE REBUILT SECTION IN PLACE

tubes were added to each section, the rebuilt boilers had additional heating surface to the extent of 42 tubes.

Although the work was done under the direction of an erecting engineer of the B. & W. Co., the actual work of rebuilding was done by the regular boiler house crew employed by the Public Service Co.

Suggestions for the Saving of Coal

By Howard C. Mead

MOST power plant superintendents are confronted with the problem of producing steam with the poorest fuel that can be purchased although they may have emphasized, over and over again, the greater heat-producing qualities of the higher-priced coal, but managements have a queer way of turning a deaf ear to a plea which involves any increase in expenditures.

Perhaps experience has taught them that savings of this nature do not run as big as described or claimed for. They have found in the past that evils in the form of poor firing and incorrect combustion creep in until the results obtained are far less than anticipated; certainly not enough to offset the higher price paid.

With this in mind it is up to the power house superintendent to issue such instructions to every man concerned with the economical production of steam as will enable him to do his work intelligently and efficiently. The chief electrician of a large pump works in Michigan issued the following set, last year, and is using the good coal again this year:

"Now that we are once again about to enter into the day of good coal, there are a few things that might be said to help each one who has anything to do with its handling. The company expects good results and economy through its use, and it is clearly our duty to see that no coal is wasted and that good judgment is used in all operations.

"The coal that has been bought for this winter's use is of the best procurable and should inspire each one of us in doing our very best so as to get all that is possible out of it.

"When you save a ton of coal you have saved your day's wages. There is no class of men in the factory who are trusted with so much of the company's money as the power plant operators and what you waste is an irrevocable loss. Do not forget that the company marks and appreciates each man who endeavors to be economical, and does not forget his good service. The power plant operators are limited to the power house alone and what seems to be wasteful of steam and coal outside of the power house should not be looked upon as a reason for our not being economical.

"Now for a few suggestions to each one—not given in the spirit of criticism:

To the Engineers

"Each engineer shall be responsible for all operations and conditions on his shift. You should absolutely know that the low and high water alarms are working on each boiler. I suggest having the fireman blow down each column in your presence when you come on duty.

"Look at the condition of the fires and see if the last men on the job have done all that they are supposed to do. Note whether they have failed to take out ashes, etc.; as that is the correct time to straighten out the difficulty and I do not expect to have the firemen complain about the ashes not being taken out, etc., on the previous shift.

"See that the feed water temperature is near 200 deg. Be sure that all lubricators are filled and pumps are in first-class condition. Take a good look at everything and if a certain thing needs attention, report it without delay.

"Make it your business to know the condition of all things when you come on duty, both in the engine and boiler rooms.

"If any fireman does not care to fire the way we think is the most economical, you should show him that you are responsible for conditions and deal with him as you see fit.

To the Firemen

"Keep your ash pit doors off and your draft closed as much as is possible so as still to carry the load. With the ash pit doors off you will get better distribution of the air under the fire. If you can't keep the boiler from popping with the ash pit doors off, you are using too much coal. When the boiler pops or gets near that point, open the feed water line to the boiler that has the lowest water line and you will find that this surplus water will absorb the heat and will thus save the heat wasted through the pop valve.

"Fire one door at a time if possible. This will lessen the smoke and will not cool off the furnace like a fresh charge of coal over the whole grate surface.

"Keep the coal from going into the ash pit and keep the floor in front of the boilers clean. Do not clean the fires unless it is absolutely necessary, as this takes fuel and when you do clean, close your damper so as to keep out as much cold air as possible.

"If you are using two boilers push one as hard as you can. Do not fire both the same and not have a very heavy load on either one; high furnace temperature gets the most out of the coal and means less work for you. Do not throw the coal any place in the furnace but look for holes in the fire to cover.

"Keep your ash pit bright at all times and do not agitate the fuel bed any more than is necessary. If the fire gets high in places, smooth it with your slice bar. There are times of light load and when other work is being done that it is not advisable to 'light fire,' but I am speaking of when one or more boilers have a good load.

"The engineer on your shift will settle all difficulties and you should go to him for things pertaining to your work.

"I expect some very good firing this winter and know that the men we now have can fire economically if they will. I do not expect to have to speak about light firing any more as this will give you an idea of what the company you work for expects and insists upon having. If we do not show excellent results with coal that is first-class you may expect the company to buy the poorest grade of fuel next year.

"I hope that nobody will feel that this is written as a criticism, but all will feel that these suggestions will make your work more desirable and pleasant, as well as enabling you to work in harmony. Let's set an example as being the most economical department in the plant, as we certainly have the opportunity to do so."

Most of the preceding suggestions are to the point, and while some seem rather rudimentary to the experienced engineer it is well to let the new and old man alike know just what is expected of him. Otherwise his idea may be rather hazy and indefinite.

At least they form the basis for a set of similar suggestions which can be posted where the men can see them.

Proper painting increases illumination, aids in light diffusion and eliminates glare. "The amount of light reflected by a given paint depends, of course, upon its color," says Walter Sturrock, General Electric Company. "White paint shows the highest reflection factor, that is, it reflects the greatest percentage of light striking it. A pure white surface will reflect light of all colors at equal efficiency. On the other hand, a paint having some color in it such as blue, for example, will be an efficient reflector of blue light but will absorb practically all red rays of light striking it. For light from Mazda lamps, a yellow paint has a higher reflection value than some of the other paints. Where white paint is not wanted, a paint of light cream tone may be used without marked sacrifice in lighting effectiveness."

Nineteen power projects are possible on the Arkansas River in Colorado, according to a report prepared by an engineer of the Department of the Interior, Geological Survey. These projects will represent a total potential power of 44,000 hp. for 50 per cent of the time and 24,000 hp. for 90 per cent of the time. The use of the water for power, however, is secondary to its use for irrigation and the cost of developing power will be relatively high because of the low heads and the small flow and because the flow cannot be regulated for the generation of power owing to the requirements for irrigation.

Small Hoists for the Power Plant

Application and Use of Various Types of Chain Blocks and Electric Hoists for Maintenance Work

MAINTENANCE work around a power plant requires that many heavy pieces of machinery be handled. This is work which must often be done with as much dispatch as possible and by the ordinary plant crew. Hand methods of handling heavy parts are always slow and tedious, particularly in view of the fact that the available help around a power plant is generally restricted to the operating crew. Maintenance work, then, must be considered as extra work to be performed by the regular crew and in such a manner that service will not be interfered with.

It is this condition which has brought about the extensive use of hoists and cranes to perform not only the routine work but to expedite the emergency work about the power plant.

Aside from the ordinary arrangements of rope and pulley tackle, which in maintenance work have many disadvantages, the most common form of hoist is that known as the chain block. It has the advantages that it

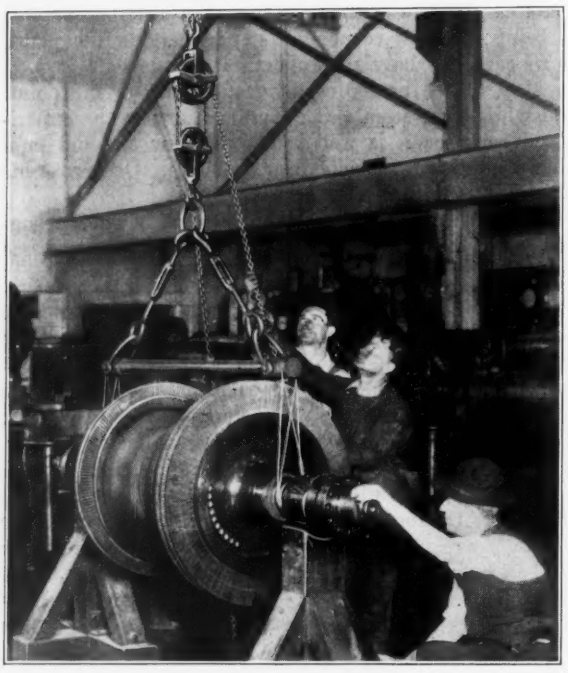


FIG. 1. DIFFERENTIAL CHAIN BLOCK AND SLING USED IN HANDLING A TURBINE ROTOR

is portable, cheap, rugged and it automatically holds its load suspended.

Three types of chain blocks are in common use; these are the differential, screw geared and the spur geared. The approximate cost of the three types is in the order 1:2:3 in the order named, whereas the efficiencies are about 30, 40 and 80 per cent, the highest figure being that of the spur geared type.

To gain a mental picture of the relative value of these three types, we may consider the conditions of time and effort in lifting a weight of one ton a distance of 3 ft. In the case of the differential block, it will require three men 1 min. and 3 sec. to perform this work. The weight once lifted is held suspended by the friction of the parts of the block.

Now then, if a screw-geared block were used, the same amount of work could be done by two men in 1 min. and 7 sec., and the weight would remain suspended by reason of the friction of the parts of the block. If we substituted a spur-geared block, this work could be done by one man in 45 sec., due to the greater efficiency of this gear and less internal friction. The load must be held suspended by an automatic brake. These illustrations show that where available man power is a factor, the first cost of a chain block is not of the greatest importance.

Capacities in which chain blocks ordinarily come are as follows:

Differential type	¼ to 3 T.
Screw-geared type	½ to 10 T.
Spur-geared type	¼ to 20 T.

It is not possible to over-emphasize the importance of the strength and durability of the chain used in any chain block. It is the most expensive single part of the block and is subjected to more abuse than any other part. It is preferable that each link be welded on its side where it supports only half the load. The friction of the links riding together over load sheaves comes at the ends of the links and not on the weld. Chain so welded operates more freely over the sheave, does not wear rapidly and is not easily kinked.

Hooks Must Not Be Overstressed

Chain block hooks, made of the proper material and properly designed, serve as a safety valve to the user. When overstressed, they should tend to straighten out without rupture. The load should always be suspended from the saddle of the hook and not from the tip. Hooks should preferably be made with a round shank which will allow them to turn in the shackles, thus facilitating the placing of machine parts.

Care of chain blocks requires nothing more than common sense. They should not be excessively overloaded; the load should not be allowed to fall suddenly onto the block and the bearings should be well lubricated. Dry bearings increase friction and chain pull and result in the ultimate replacement of parts through excessive wear.

Chain blocks are usually provided with a swivel hook or eye by means of which they may be conveniently tied to any structural member which will support the load. They may be secured to a structural member of the building or boiler frame, a tripod or a specially constructed horse. Chain blocks are particularly advantageous where overhead clearances are small. For permanent installations over engines, turbines, pumps, etc., the chain block may be hooked to a four-wheel trolley which runs on a single I beam as a track. Trolleys are in general of two types, those which are geared and which are moved by means of a chain and a chain wheel and the more simple type which is not geared but is moved by swinging or pushing the load.

Of wide application in handling materials in power plants is the electric hoist. It finds its application in the distribution of coal to boiler hoppers and the disposal of ash. Due to the distances which are usually traveled, the electric hoist is generally mounted on a trolley which is motor driven and which travels on a single I beam track.

Control of the electric hoist is effected in three ways. First the control push button or cord may hang from the hoist, to be operated from the floor. In this case the operator must follow the load. Second, the hoisting and travel of the hoist may be remotely controlled from one central station, in which case the full length of trackage should be in full view of the operator. Third, the hoist may be equipped with a cab so that the operator rides with the hoist and so is with the load at all times. This scheme is good from the safety view point and it keeps the operator off the floor where various obstacles may hinder his movements.

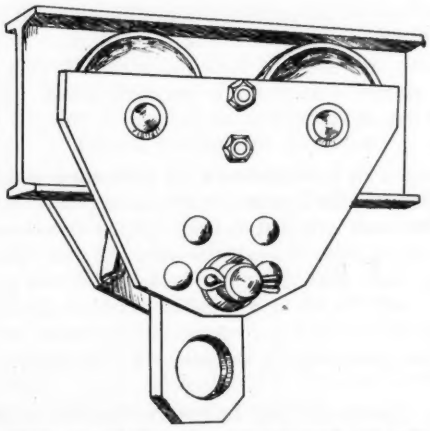


FIG. 2. STEEL PLATE TROLLEY WHICH USES AN I BEAM FOR A TRACK

Electric hoists should be equipped with limit stops, so that when the load reaches its maximum travel in either direction the brakes will be automatically set and it is not possible to operate the hoist motor again until its direction of rotation has been reversed.

Capacities of Electric Hoists

Electric hoists are built in capacities ranging from ½ to 6 T. Their maximum lift is about 15 ft. Hoist motors vary in size from 2 to 10 hp., and trolley motors vary from ½ to 4 hp. The hoisting speed of the smaller sizes is from 30 to 60 ft. per min. while for the larger sizes the hoisting speed is from 20 to 40 ft. per min. Trolley speeds vary from 300 to 350 ft. per min. on the smaller sizes and from 175 to 225 ft. per min. on the larger sizes. The weight of an electric hoist, including the trolley, varies from 550 to 3200 lb.

When specifying electric hoists, the following points should be given careful consideration: Maximum load, maximum lift, distance from floor to bottom of I beam track, hoisting speed at maximum load, alternating or direct current, voltage, phases and cycles. Speed of trolley must also be considered as well as location of control, approximate number of lifts per hour, minimum radius of track curves, maximum and minimum lengths of runs and finally the conditions of service, whether exposed to the weather, dust or acid fumes. The special features of each installation should also be studied and specified.

Reduce Costs by Stopping Ammonia Leaks

Inspection of the New Pipe Work, Use of High Grade Materials and Frequent Tests Will Save Ammonia. By A. G. Solomon

COST OF AMMONIA used per ton of ice produced varies greatly in different plants. This cost is a surprise to many engineers because few of them believe that it amounts to much. Every engineer should check up at the end of each month or year and compare the cost of ammonia per ton of ice produced with what it was during the corresponding period of the previous year. Cost of ammonia will be based entirely on two things. One is the loss of ammonia due to leakage, the other is the loss through decomposition. The former can be prevented while the latter loss is a natural one and cannot be avoided.

Leaks may develop in any part of a refrigerating system, so to prevent leakage a constant watch must be kept on all pipe work and the apparatus which makes up the complete plant. The installation of new work must also be given proper consideration.

It would be a money saving proposition if the erecting of ammonia equipment were given the same attention now that it was 30 yr. ago. Install the system right and the added expense will be less than the amount spent in doing over the things that were carelessly done in the first attempt. The following are a few simple and plain suggestions which are safe to follow when ammonia pipe work is being made up. Use good pipe. This does not mean that extra heavy pipe must be used for all the high pressure side of the ammonia system. There are many manufacturers putting standard pipe on the market whose output is suitable for all high pressure ammonia work. Selected full weight standard pipe is used almost entirely now for ammonia condensers and it gives good service. As a rule, it is seldom that the pipe itself gives out unless there is a good reason for such failure.

Standard pipe is not as thick as extra heavy and will break more easily at the threads if undue strain is placed upon it. It must be remembered that pipe work should not be erected so it is out of line and under a strain. Take all measurements carefully and put the pipe work up level. Use proper supports and hangers. A job cannot be called complete until the hangers are in place and everything painted or covered. Hanging pipe by means of wire and rope is all right during the erecting period but substantial iron hangers must be in place before the pipe work is put in service.

In most plants there is one place where the pipe work must be watched closely for pitting. That is around the atmospheric type of ammonia condenser. Pipe work will not last long where it is subject to splashing water. The condenser pipes that are wet all the time will not pit any more than pipe that is dry all the time but where water splashes on the pipe, then dries and splashes again, pitting will start. This is more quickly noticeable if the pipe is hot as in the case of the discharge line from the ammonia compressor.

Another weak point in the piping system is where the flanges or return bends are made up on the condenser pipes. The pipe has been reduced in thickness and strength by the cutting of the threads and rust or pitting will soon cause leaks. See that the circulating water flows uniformly over this part of the condenser. The water will then de-

posit a protecting layer of scale over the exposed threads and prevent pitting.

Keep Bolts Free of Rust

Watch bolts for rusting. When new work is put up or when new gaskets and bolts are put in flanges, give the bolts a coating of graphite and oil. At least once a year clean the rust and scale from the bolts and give them a coat of paint. If this is done, a flange can be tightened up in case of a leak. Too often a small leak at a flange will be allowed to continue just because rust prevents the bolts from being tightened. After new work has been installed or the overhauling of the plant completed, every bolt should be tried for tightness not later than 3 da. from the time the plant is put in operation. A week later every bolt should again be taken up. It is neglect of this follow-up system which causes leaks to start at flanges and valve bonnets.

Thickness of the gaskets used in flanges must be given some thought. As a rule, thin material is best but there are many flanges which require thick gaskets or the flange will face up and still not press the gasket tight enough to prevent leakage. Rubber or composition gaskets will meet nearly all requirements and give good service. Rubber or composition will roll or tear when a twisting strain is put on it. Lead gaskets are best for such places as valve bonnets where the bonnet is of the screwed instead of the flanged style; the lead will give no trouble as it will press into place and stay there. In places where an extremely narrow gasket is needed lead will give satisfaction when other materials will fail.

Do not use inferior material just because it is handy or in stock. The difference in price between the best and the poorest gasket material is not enough to think of when we realize how much depends on the gasket. When flanges are taken apart it is best always to put in a new gasket when connecting up again for in that way you are sure of a tight joint.

Many engineers prefer to bend pipe whenever possible instead of using fittings. It makes a neat and good job and does away with some screwed joints. When bending is done use extra heavy pipe. Common pipe may be all right but it is sure to be weakened by the stretching of the material on the outside of the bend.

When it is necessary to reduce the size of pipe at a fitting and the proper reduced fitting is not on hand or easily obtained do not take a chance on using a common cast-iron bushing. Regular ammonia bushings should be used. If such bushings cannot be obtained or made a reduced coupling will be found safe. Reduced couplings are made of malleable iron and will not crack or split like cast-iron bushings. The use of cast-iron plugs is also a dangerous practice. Some cast-iron plugs are of the solid kind and are safe but most of them are nothing but a shell. A nipple and a malleable cap should be used instead of a cast-iron plug.

Always Allow for Pipe Expansion

Rigid pipe work is another cause of ammonia loss by leakage. In connecting several stands of ammonia condensers or other coils together the connections between the stands or coils and the header should be made as flexible as possible. This can usually be done by placing the header a little distance away from the coils and using pipe bends between the coil and the header. When coils are connected in a close rigid manner to a header there is always danger of cracking a flange when tightening up the bolts.

Now that the sweat or soldered joint is not in general use care must be used to see that the threads on the pipe and in the fittings are good before trying to make a tight joint. A mixture of litharge and glycerine is about the best cement to use on ammonia work. Mix it thin and it will get into any small defects of pipe or fitting. Graphite and oil or oil alone are often used and give satisfaction except when the threads are not good.

Some loss of ammonia is always accounted for through the packing of the ammonia piston rod. If good reliable packing of the exact size is used and the operating of the machine is given proper attention the rod packing will give little trouble and the ammonia loss will be small. If the packing does leak, it is foolish and wasteful to let it continue. Shut down and pack the rod and stop the constant drain on the system.

Direct cost of the ammonia is not the only loss chargeable to leaks. As the ammonia escapes, there will be a diminishing amount put into the system. This means that the charge of ammonia is becoming smaller with the result of loss in capacity or an increase in the cost of production.

If we are to save ammonia by preventing leakage we must have a regular system for the finding of leaks. As a rule, most leaks are first noticed by the fumes and our noses are the guides to locate the leaking point. But there are many leaks that can never be found by the smelling method. Sulphur sticks or candles should be used at regular intervals for the purpose of finding leaks and every part of the system should be gone over thoroughly.

Watch Carefully for Leaks in Overhead Piping

Do not neglect the pipe work that is on the roof or at a height above the ground. The ammonia from a leak in an overhead line will blow away and therefore can easily be overlooked. An engineer who really tries to prevent ammonia loss will never be satisfied if a sulphur stick will cause a cloud or even a trace of smoke at any point in the exposed parts of the system.

In a plant having any double-pipe equipment or apparatus of the multi tube type tests should be made once every 24 hr. The time spent and the trouble taken will be fully repaid if but one leak is found during a season. A simple and sure way of testing this kind of equipment is to shut off the inlet and outlet water valves of one coil at a time. Leave the valves closed for about 5 min. and then draw a sample in a glass and test by smelling and also with Nesler's solution or litmus paper. The manufacturers of ammonia will furnish both the reagent and the sensitive paper. If there are a great many stands of double-pipe condensers, all of them do not have to be tested one after the other. Test some the first thing every morning, some during the forenoon and the rest during the afternoon and evening.

Small leaks in the coils of the ice tank and in shell and tube type brine coolers are hard to locate. A test of the brine by the use of Nesler's solution or litmus paper will tell if there is a leak of fair size. A small amount of ammonia can easily leak into the brine of an ice tank during a whole season and its presence never be known. The proper time to guard against leakage in the coils is during the time that the ice tank is being overhauled.

Stop the Leaks

By A. R. Knapp

I HOPE to live to see the day when some enterprising manufacturer of power supplies will see fit to send to every engineer in the land a nice gilded frame to hang over his desk with these words inscribed thereon—"STOP THE LEAKS." It would give a finishing touch to many engine rooms, and would be a constant reminder to the chief that his job represents something more than keeping up steam and grinding out power.

There is hardly a plant operating that does not have its quota of leaks. By leaks I mean losses—preventable losses—that can be detected and remedied by the application of a little energy on the part of the man in charge. It is such small losses here and there that will most surely lower the efficiency of a power plant. When the owner figures that it is costing too much to operate his plant, a fertile field is opened for the approach of the central station expert, and the engineer may find himself looking for another connection.

Boiler Losses Are Excessive

One does not have to seek far to find the source of preventable losses in a power plant. Take the boiler, truly the fountain head of power. It is a greatly abused piece of apparatus, and the wonder is that it continues to perform its duty as well as it does. The efficiency of a steam boiler is miserably low at best, and every effort on the part of the engineer expended on this unit will pay good dividends. Baffling may be down, allowing the hot gases to short-cut to the stack. Leaky blowoff valves represent another positive preventable loss so often neglected.

Feed water is often fed to boilers far below the temperature that could be obtained by a little careful planning on the part of the engineer. All feed water piping should be covered with the best grade of covering obtainable. The writer was once employed in a plant where there were 125 ft. of 4-in. feed water pipe between the pumps and the boiler drums, every foot of which was bare. At the far end of the line, the pipe was cool enough to lay the hand on without discomfort. This condition existed in a large state institution, but nobody seems to worry about state institutions. Every foot of bare steam piping is likewise another source of preventable loss.

Cracks in the boiler setting represent such an easily detected loss that one would imagine there would not be a boiler wall in the land showing these small crevices. Yet they exist in hundreds of plants, and are on the job 24 hr. every day, admitting cold air to the boiler where it is least desirable.

Pumps Need Periodic Inspection

Steam pumps about the plant are often the cause of losses. Reciprocating pumps are great steam eaters, taking steam practically the entire stroke. It is no uncommon occurrence to find these pumps operating for years with the interior of the steam end never seeing the light of day. Good practice calls for periodic inspection of the steam cylinder. By this means, leaky piston rings and grooved and cut cylinders can be detected. The water end is allowed to run until the pump fails to deliver the necessary amount of water. It is far more economical, and better service results when pumps are kept properly packed.

Another point is that the movable parts should be oiled occasionally. A pump is no camel in this respect, and a little oil applied to arms and levers greatly prolongs the usefulness of these members. In passing, it may be noted that there is no valid reason why steam and water should be squirting from stuffing-boxes. A little attention will stop these unnecessary leaks and improve the looks of things considerably.

Oil Wasted on Engine Cylinders

Waste of oil in the average engine room (especially small engine rooms) is another item that I cannot pass by without mention. It is a safe bet to say that the majority of engine cylinders are over-lubricated rather than properly lubricated. This is due largely to fear on the part of the attendant or engineer that the cylinder may go dry. Excessive cylinder oil often plays havoc with the boiler, and is usually the reason why the less efficient closed type of feed water heater must be used when pure steam is necessary in manufacturing. Excessive oil will get into the heating system, and eventually cause no end of trouble.

Oiling engines by hand is a nuisance and wasteful of oil. The gravity oiling system piped to engine bearings is much more reliable and is certainly less wasteful of oil.

Check Up on Factory Losses

Out in the factory preventable losses are numerous. Take the steam piping for instance. A defective gasket in a steam main may be blowing steam. Multiply this by numerous other steam leaks of like nature, and a prodigious amount of steam can be wasted in a short time. Leaky valve stems represent another very apparent loss. Piping in tunnels often leaks due to poor supports or lack of supports. The leak may go on undetected for months. Tunnels are usually cramped and hot, and for this reason many men are reluctant to report leaks in these places.

Steam traps are generally placed in such out of the way places that they seem to be entirely forgotten by the engineer. All traps will function properly for a time, but the day comes when parts become worn, and seats cut, then blowing through results. It is a wise plan to inspect your traps at regular intervals.

Line shafting is another article of equipment that seldom receives the attention it deserves. When was the last time, Mr. Engineer, that your line shafting was tested for alinement? Shafts out of line can waste a large amount of power, and this loss goes directly to the coal pile. Poor lubrication of shafting is another reason for wasted power.

Belting is a greatly abused article. In some plants a systematic effort is made to keep belts pliable and in good running condition. But in many places, a new belt is put on, and forgotten. Often belts are run in hot places. Without proper attention, a belt soon becomes dry and hard, cracks in numerous places, and fails to deliver the power applied to it. In a certain plant, ground rosin is the only treatment applied to belts. When a belt squeaks and slips, a handful of rosin is sprinkled on the belt face, which stops slippage for a few days. One can imagine the condition of belts in this plant—dry, cracked, and with the inner surface pulled off on many drives.

Belting should be maintained as any other piece of equipment. The occasional application of neatsfoot oil applied with a brush will keep them pliable and in good condition.

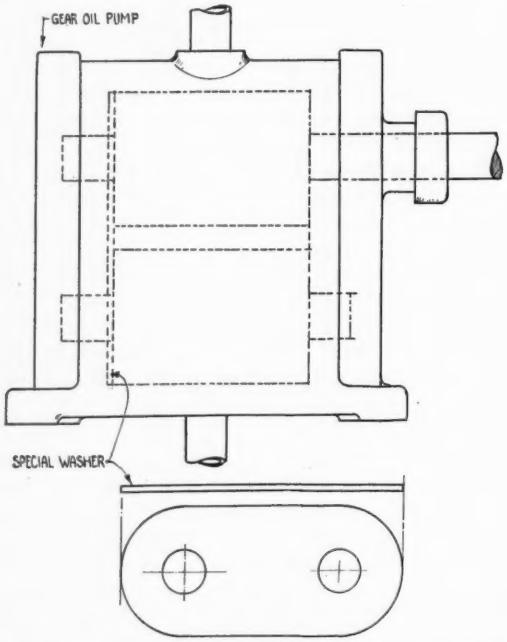
Clean up, and check up on the equipment regularly, for your own as well as the owner's benefit and profit.

Leakage Prevented in Gear Oil Pump

GEAR OIL pumps, such as are used in conjunction with various machinery, will fail to pump to full capacity when worn.

This is the type of pump in which two pinion gears revolve jointly, the oil being brought into one side of a casing and forced out at the opposite side.

Examination of a worn pump will show, first, wear of the bearings, and second, wear in the gear casing at the ends of the gears. The top of the gear teeth do not come into contact with the casing or bear on each other



SPECIAL WASHER TAKES UP END PLAY AND PREVENTS LEAKAGE

and consequently do not wear. Likewise the faces of the gears in contact will not prevent the pump from accomplishing its work as it is through this space that the oil is carried or forced through the pump.

Repairs which were made to one of the these pumps recently present a new and serviceable idea for restoring them to working condition.

Bushing the bearings is part of the repair but this is not new. The feature in the repair consists in placing in one end of the casing a spacing washer, shaped as shown in the accompanying sketch. This consists of a piece of brass, the thickness of which is determined by the play in the pump, with two bored holes spaced to the gear distances to shut off the leakage. This, I have found, is a simple but serviceable wrinkle to salvage pumps which are not now working.

Washington, D. C. G. A. LUERS.

Burning Small Sizes of Anthracite

ON PAGE 617 of the June 1 issue of Power Plant Engineering, Mr. Wakeman takes exception to Mr. Fisher's article in the April 1 issue. I fully agree with Mr. Fisher. Soft coal fires will burn through in holes unless constantly leveled and kept covered over and to burn No. 1 buckwheat or anthracite screenings will require a grate with smaller air space than is necessary to burn sawdust because anthracite coal in any size has no coking qualities. To burn small size anthracite coal clear requires a pin hole grate or 3/16-in. air hole space grate and the fire is carried about 2 to 3 in. thick. A thicker fire will not allow enough air to come through for complete combustion and the fire requires frequent cleaning to prevent the ash and clinker accumulating on the grate to a depth which would stop the air flow through such small air holes. In many plants anthracite screenings are not always obtainable and it is not easy to change grate bars to burn the soft coal which requires ⅜ to ½-in. air space.

A mixture of soft coal and screenings may be used with ⅜ or ½-in. air space grates. The soft coal cokes up and the screenings do not fall through in any appreciable quantity after the fires have been started. A mixture of half screenings and half soft coal, or two of screenings to one of soft, often as high as four parts screenings to one part of soft coal is used, depending on the air space of the draft, the draft of the stack or forced draft fan, and the demand on the boiler for steam and whether or not they may be over-loaded.

Cleaning of fires every two hours where anthracite coal is burned is a hot and laborious task and dumping grates are frequently used to save time and labor, as it is almost impossible to clean five or six fires in succession without loss of pressure. Screenings fires will burn through in holes quickly when being built up even with pinhole grates and require light sprinkling of the coal on the fuel bed. Where forced draft fans are used, as they usually are with anthracite screenings, more cold air rushes through these holes, than where natural daft is used. Few plants can burn small size anthracite without a forced draft fan as the highest stacks do not give sufficient draft for this kind of fuel. I had one plant of 9 return tubular boilers where we burned 35 T. of soft coal in 24 hr. We put in pinhole grates and forced draft fan, for although we had a 9½-ft. brick stack 175-ft. high, we could not get sufficient draft from the stack alone to burn this small size fuel. The addition of the forced draft fan cut the amount of coal

down to 26 T. in 24 hr. I also had one plant of 7 return tubular boilers where the cost of fuel was reduced by the use of pinhole grates and forced draft fans, using anthracite screenings in place of soft coal. The main difficulty is to keep the holes covered in the fuel bed, as the fires had to be kept so thin to get the right draft and temperature that they burned through quickly.

This action is due to the difference in the size of the coal. Screenings contain all sizes from ¼-in. down to dust and in firing the ¼-in. size all lands on one spot of a grate, while the dust or smaller size lands in another place, the larger ¼-in. size allows the air to pass through more freely and combustion is rapid, while the finer size and dust coal burns slowly. Hence, the fire burns through in holes quickly. The buckwheat size is about ⅛ in., and is screened to take out the finer dust size and burns more evenly, but this size requires such a draft that it fairly lifts from the grates and is hard to fire. The cost of screening to this size drove the buckwheat size of anthracite out of the market and it is now sold as screenings of ¼-in. size and less, often called anthracite dust, which can be burned with forced draft and proper size and height of stack on pinhole grates, or mixed with soft coal and burned on ⅜ or ½-in. air space grates with natural draft as desired.

Where the stack is small or short for the size and number of boilers of the plant, there is a pressure built up in the flue tubes and furnace above the grates, which causes the gases to come through the brick work of the setting, which causes rapid destruction of the brick settings. In one plant the writer had four return tubular boilers with a small stack, just sufficient for three boilers. It was large enough when only three boilers were in operation but at times four boilers had to be used and the pressure built up to such an extent that the flame would come out of the furnace doors 3 ft. when the firemen were coaling over the fires. When soft coal was mixed with the screenings, the back draft drove flame from the doors as much as 6 ft. This trouble was overcome by putting up a small high steel stack beside the brick stack. If the stack is just sufficient in size and height to carry away the gases from the furnaces and a forced draft fan is used, the same back draft troubles are experienced each time the fan is overspeeded. For this reason many owners prefer to use a forced draft fan and an induced draft fan in place of a forced draft fan and stack, as the induced draft fan can be speeded up to any stack draft desired to carry away the gases from the furnace and often serves the purpose of both fans for a time, when repairs are made on the forced draft fan. Small sizes of anthracite coal can be burned to better advantage with such equipment.

Cambridge, Mass. R. A. Cultra.

In the Good Old Days

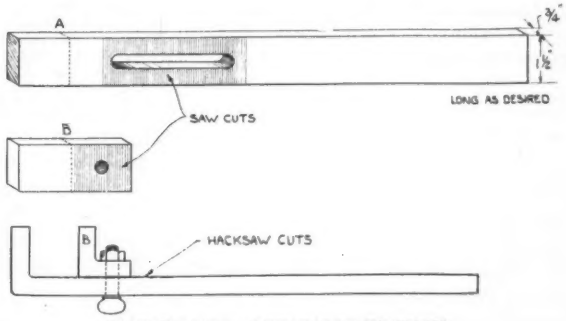
In the May 1 issue of Power Plant Engineering, the article on Muck-Hole Mechanics brings to mind several of my own past experiences. I remember one time in my early wandering I took a job as engineer for a sawmill in Kentucky. When I arrived, they said the plant had run only ten days the previous month due to engine trouble. I went out and looked the engine over; it was a little past the stage of junk but I went to work and in two days had the valves adjusted so it would pull the load. Then I looked over my boilers. They were of the return tubular type. When I asked the fireman when they had been washed out and cleaned internally, he remarked that he had been there 6 yr. and it was the first time he ever heard tell of any such foolishness as cleaning the inside of a boiler. So on Sunday I had one boiler off and looked into it. How it ever made steam is a mystery to me.

When I called the superintendent's attention to it, he was in no way moved until I told him that unless he cleaned it up and treated his water they would have to buy new boilers inside of 6 mo.. I managed to keep things going for 2 mo. by working day and night and as I was paid for overtime, the company decided I was making too much money and ordered the overtime cut out. The next day one of dutch oven furnaces in which we burned wood slabs and saw dust caved in and I packed up and quit. I was, however, ahead of Brother Brown; I received my wages in full. Though I have been on a few jobs where I didn't.

New Kensington, Pa. James H. Cox.

Handy Adjustable Wrench

Being in need of a long handled adjustable wrench with rather a large opening, I made one as shown in the accompanying sketch. I have found it a mighty handy



EASILY MADE ADJUSTABLE WRENCH

tool and it is one which anyone can make if he has a hack saw and drill. Two pieces of steel and a wing nut are all that is required. After the pieces have been drilled, bent and cut to shape they are tempered. The saw cuts on the part B are to prevent movement after the thumb screw has been tightened.

John Thorn.

Acetylene Welding

A. R. Knapp's article on page 500 of the May 1 issue on acetylene welding is both timely and interesting and should be taken seriously by those who as yet have not a welding outfit in the plant. They have been used for years in the plant in which I am employed and have saved a good deal of money both in time saved on repair work and in material.

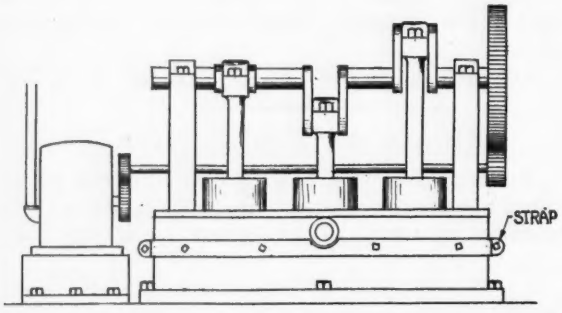
One small instance in which it was used to good advantage was in replacing some broken off foundation bolts on an engine. They were broken off even with the bed plate and to put new ones in it would have been necessary to do a lot of cutting and drilling into the foundation. This would have taken a lot of unnecessary time and labor.

Instead a small hole was cut under the base of the engine around the broken bolt and another piece with a long thread was made and put down on to the end of the broken off bolt. The ends were then welded together with an acetylene torch, the welder lying on his side to do the work. The holes were then filled with grout and the bolts were as good as new. This saved much time and labor which are costly items.

Hudson, N. Y. D. L. SIMMONS.

Repairs to a Pump

WHILE WORKING in New York one winter, one of the pumps in our plant became so badly frozen that we could not run it at all. We thought we would get a new base for it and accordingly wrote to find out what it cost. The



CRACKED DISCHARGE CHAMBER REPAIRED WITH A STRAP

answer was $105. This was rather excessive, we thought, so decided to make a repair ourselves.

After the pump had been taken down and cleaned, we discovered that the break consisted of a crack running through the discharge chamber and extending across the cylinder. A bar of iron 4 by 1-in. was made to go around the cylinder, to be tightened with bolts. A good coating of iron cement was prepared and when the job was ready, it was put in and the iron strap was tightened. Four bolt holes were also put in the front side and tightened in cement. After the cement was hardened, the valves were ground in, then the pump was put together and started up. After we were convinced that it would hold water, it was put on boiler feed service and has been running that way ever since. That job cost us just $12.50.

Utica, N. Y. M. M. BROWN.

Belts and Belt Dressing

IN THE June 1 issue of Power Plant Engineering, page 603, the writer read with interest the advice to apply some animal oil such as neatsfoot oil to leather belts that are in a dry warm place. It is said that they require some oil to make them pliable and to make them grip.

It is true that belts, when allowed to become dry, will become weak and will wear out prematurely. It is also true that putting dry powdered resin on a belt to make it pull is a bad thing for the belt. The writer is surprised, however, to see this recipe for keeping belts in a good pliable working condition during the summer time: "Beeswax, 4 lb.; pitch, 5 lb.; resin, 3 lb.; neatsfoot oil, 13 lb."

If resin in dry form and alone is bad for belts, it is equally bad when mixed in any preparation just as arsenic is bad for the human system whether taken alone or with something else. There should be no resin in belt dressing of any kind—either liquid or stick dressing.

As for neatsfoot oil, before applying it to leather belting, a good test that anyone can make is to apply some to a short piece of belting. Put on enough so that it will penetrate into the belt. It will be found that neatsfoot oil makes the belt unusually flabby and soft and that it will stretch easily. Worse than that, if kept in a warm place the leather will soon begin to rot and the leather fibers will be harmed. There is no question but that the application of neatsfoot oil to leather belting kept in a warm place results in shortened life for the belt.

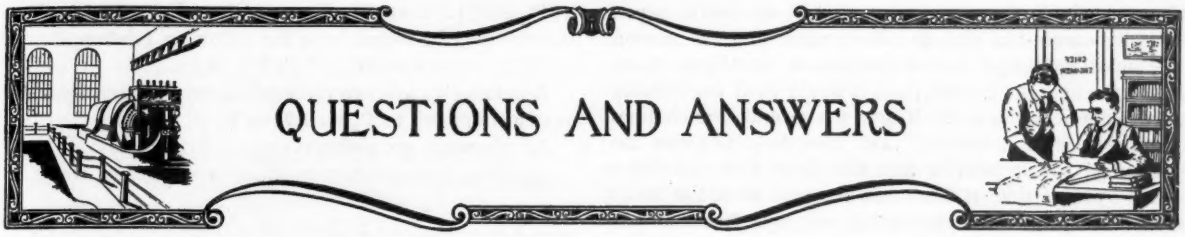
There is no good reason why neatsfoot oil, castor oil, boiled linseed oil, tallow, beeswax, pitch and other similar harmful substances should be used as long as there are good high grade belt dressings on the market which do not contain harmful ingredients. Reputable manufacturers of belt dressings have devoted many years of careful study to the development of belt dressings that are preservative and that add to the life of the belt rather than detract from it. Castor oil and neatsfoot oil will cause decay after a while and will eventually do more harm than good. Temporarily they may appear to benefit the belt and they may actually improve the belts' tractive power, but why use them when a preservative, beneficial belt dressing is obtainable?

While it is true that castor oil is oftentimes better than nothing at all, the writer is at a loss to understand why castor oil is so frequently recommended for application to belts when it has been proven time and again to be harmful to the belt's fibers. What is more, it does not prevent slip as well as does a treatment made especially for belts.

There is an actual example that the writer has in mind, that of a 12-in. belt which connected a 4-ft. driving pulley, running at 213 r.p.m. to a 14-in. driven pulley. This belt drove a 682-light dynamo, and even when treated with castor oil, had to be run tight with a man constantly at hand to prevent it slipping off the pulleys. When the belt slips, the lights of course are bound to flicker. Later on, a belt dressing, made especially for belts, was applied and the drive was so improved that an 850-light dynamo was substituted for the 682-light unit. In spite of the 25 per cent load increase, the same belt now runs quite slack, does not slip, and requires no attention.

One of the objections to castor oil is that it is gummy. The gum in solution is carried in and among the belt fibers as far as the oil penetrates. The liquid parts of these oils slowly dry out and leave the gummy element, which continues to stiffen, and sooner or later becomes hard enough to crack. When these elements crack, the belt fibers crack with them. This explains the fine transverse cracks, particularly across the backs of belts which have had initial or subsequent treatment with castor or linseed oil. It is these same gummy elements that make a belt so treated look slick and smooth, and, in a measure, lessen its tendency to slip. Both of these oils also decompose into harmful fatty acids. Proof of the decomposition of castor oil can be had by placing some in an uncorked bottle, setting this in strong sunlight or in a warm place and in time observing the changed appearance.

Newark, N. J. W. F. SCHAPHORST.



Is the Expansion Valve at Fault?

I WOULD appreciate it if some of the readers of these columns who have had experience in the matter will explain just how to regulate the expansion valves on an ammonia ice making system to get the best results. We have two ice making tanks, one containing 836 cans and the other 240 cans. The larger tank operates on the flooded system and is provided with an accumulator having a tell-tale pipe. I have tried keeping this tell-tale frosted and I have tried keeping it dry but the net result is always the same.

We carry our condenser pressure from 175 to 200 lb., in hot weather, and the suction pressure from 10 to 16 lb. If we carry a higher suction pressure, liquid ammonia comes back and the machine becomes frosted over and begins to pound. Sometimes we can get the temperature down quite easily and at other times not. The large tank has four valves and the small tank two. C. M.

Paint for Use in Contact with Oil

WE HAVE recently installed a large steel tank which is to be used as a reservoir for engine oil as it comes from the engine. This oil will be warm and will contain some water so that there will be an accumulation of water in the bottom of the tank most of the time. I would like to paint the inside of this tank so as to check corrosion but I do not want the paint to affect the oil and I am at a loss to know what kind of paint to use.

Have any of the readers of Power Plant Engineering had any experience with paint for this purpose? If so, I would appreciate hearing about it. C. B. S.

Is the Governor Over Sensitive?

I AM at present operating two Vilter-Corliss engines in an ice plant, one 12 by 36 in., running at 64 r.p.m. and one 10 by 20 in., running at 84 r.p.m. The larger unit cuts off at 1/7 and the smaller at about 1/5 stroke. When running up to speed, the governor on the small engine holds its position steady but the governor of the large unit, with a constant load, works continually up and down with a movement of from ⅛ to ⅝ in.

What is the cause of this erratic performance and how can it be remedied? W. B. C.

Oil Tank May Float

IN A neighboring plant they are installing oil burners and two underground storage tanks for the crude oil, having a capacity of 15,000 gal. each. The engineer on the job has laid out a plan calling for 20 T. of concrete for a foundation with foundation bolts and steel straps, ½ by 2½ in. over the tanks, bolted down to this foundation with concrete covering over the top.

He claims all this weight is necessary to hold down these tanks, as crude oil has a certain lifting power, and when full will rise if not held down. As this is a new one on me, kindly advise me whether there will be any lifting of the tanks. G. H. W.

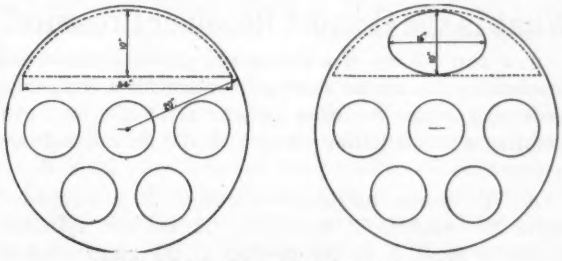
A. Any water-tight vessel, located below ground where it is likely to be entirely submerged in water at times, must be anchored down or else a buoyant effect will manifest itself and the vessel, whatever it may be, will have a tendency to float just like any boat.

Water at its maximum density weighs about 62.5 lb. per cu. ft. and any object weighing less than this will be buoyant in water.

It is because of this buoyancy that sometimes you will find that condenser room pits which have to be located below the flood water level are frequently anchored down to bed rock or weighted in some way to prevent flotation when they are entirely surrounded by water. It is because of this, then, that the oil tank which you mention must be weighted down. A 15,000-gal. tank will displace approximately 127,000 lb. of water when completely submerged. In order to prevent flotation, then, the empty tank, with whatever additional material is used to weigh it down, must weigh not less than 127,000 lb. or say, 61 T.

Bracing for Boiler Heads

WE HAVE a 40-in. tubular boiler, the front and rear heads of which are shown in the accompanying sketch. I would like to know how many and what size crow-foot braces should be used to withstand a pressure of 200 lb.



AREAS OF BOILER HEADS TO BE STAYED

The unsupported sector of the head is 34 in. wide and has a rise of 10 in. One head has a 10 by 16-in. manhole, reinforced to compensate for the material cut out. Please show a simple formula, one that can be easily applied for all practical purposes. J. C. B.

Hammering in Water Piping

OUR WATER tank is about 70 or 80 ft. above the hydrants; it is 6 ft. by 6 ft. and holds between 4 and 5 ft. of water. The supply line is 1¼ in. all the way. Why is there a series of hammering knocks heard when the hydrant is shut suddenly and not heard when it is shut slowly? Is the pipe running full of water when the hydrant is wide open or are there air bubbles rushing in

when open? Is the pounding caused by air in the pipes, or is it because the pipe is full of water and the motion is stopped suddenly? Is the pressure at the 1¼-in. opening of the hydrant greater than it would be if the opening were reduced to ½ in.? There are several branch lines on this line; is it possible that these help to cause the pounding? Is it possible that the water runs out faster at the hydrant than it flows into the pipe from the tank? If it were possible to have a tapered pipe from tank to hydrant would the knock still exist? C. C.

A. When a stream of water is moving along in a pipe line it possesses a certain amount of kinetic or velocity energy. If the flow is suddenly stopped, this energy is converted into potential or pressure energy and considerable pressure builds up in the line. The rate of pressure increase corresponds with the rate of decrease in flow, hence if your valve is closed suddenly, the pressure at the valve increases suddenly and the knock such as you describe results.

Unless your hydrant is arranged so that it is supplied from a vertical length of pipe leading down directly from your overhead tank; there will be no air bubbles when the valve is opened.

As long as the water in your hydrant line is at rest the pressure at a 1¼-in. opening would be the same as that at the ½-in. opening, providing the two were at the same level. When the water is in motion however, the flow will be greater through the 1¼-in. opening, consequently the friction loss in the pipe leading to the opening will be greater. This condition would tend to make the pressure at the 1¼-in. opening somewhat less than that at the ½-in. opening.

Branch pipes would probably have no effect on the hammering.

It is not possible that water would run out of the hydrant faster than it runs into the supply pipe at the tank.

A tapered pipe, such as you suggest, would have no effect in reducing the knock.

What Is the Correct Receiver Pressure?

Can you tell me of a simple and practical method of determining the correct receiver pressure for a compound condensing engine having a cylinder ratio of 4 to 1 and operating with an initial pressure of 150 lb. and a 26-in. vacuum? E. A. R.

A. To secure maximum efficiency in a compound engine the amount of work done in the two cylinders should be equal, i. e., the product of the mean effective pressure and the swept volume in the high pressure cylinder should be equal to the product of the mean effective pressure and the cylinder volume of the low pressure cylinder. For a non-condensing unit this condition is met approximately when $P_2 = P_1 \div R$, where P_2 is the receiver pressure, P the initial pressure and R the cylinder ratio. The cylinder ratio here should be so designed that $R = \sqrt{(P_1 \div P_3)}$ where P_3 is the back pressure. In this case $P_2 = \sqrt{(P_1 \times P_3)}$.

For condensing engines the value of P_3 is sometimes so small that the value of R, found by the last equation, may be excessive for practical purposes. In this case P_3 may be replaced by some limiting value, P_4, which may vary from about 3 to 6, depending on the judgment of the designer. The cylinder ratio would then be $R = \sqrt{(P_1 \div P_4)}$. Then if $R_4 = \sqrt{(P_1 \div P_3)}$, the receiver pressure may be found from the following relation,

$$P_2 = P_1 \div \sqrt[3]{(R \times R_4^2)}.$$

Assuming an average value of P_4, say 4.5, this equation may be simplified to $P_2 = 1.28 \sqrt{P_1} \times \sqrt[3]{P_3}$.

All pressures are absolute.

Applying this equation to the values specified, we find:

$$P_2 = 1.28 \sqrt{165}\ \sqrt[3]{2}$$
$$= 1.28 \times 12.85 \times 1.26$$
$$= 20.7 \text{ lb. abs. or } 6 \text{ lb. gage.}$$

The value for P_3 given, 2 lb. per sq. in. corresponds approximately to an absolute pressure of 4-in. of mercury, which corresponds to a vacuum of 26 in., referred to a 30-in. barometer.

Safety Valve Capacity

How is the discharge capacity of a safety valve found? Specifically I want to know how many square feet of grate surface can be handled by a 4-in. bevel seated valve? W. W. C.

A. The extent of grate surface that can be safely handled by a given size safety valve depends upon a number of factors, among them the maximum rate of combustion, the heating valve of the fuel and the maximum boiler pressure allowable. The American Society of Mechanical Engineers' boiler code gives, for safety valves with 45-deg. seats, the equation

$$V = 161{,}000 \times P \times D \times L$$

Where V is the number of B.t.u. in the fuel that can be handled by the valve per hour, P is the maximum allowable working pressure, absolute, D is the diameter of the valve and L the lift.

Tables of safety valve capacities and dimensions indicate that a 4-in. valve will have a maximum lift of 0.12 in. If we assume 150 lb. maximum allowable pressure then

$$V = 161{,}000 \times 150 \times 4 \times 0.12$$
$$= 11{,}592{,}000 \text{ B.t.u. per hr.}$$

If it is further assumed that coal having a heating value of 12,500 B.t.u. per lb. is burned, with natural draft at a maximum rate of 20 lb. per sq. ft. of grate per hour, then the grate area that can be handled by the valve will be

$$A = 11{,}592{,}000 \div 12{,}500 \div 20$$
$$= 46.4 \text{ sq. ft.}$$

If forced or induced draft is employed or if the natural draft is particularly heavy then obviously the grate area that can be taken care of by the safety valve will be reduced.

Efficiency of Double Riveted Butt Joints

In a double zigzag-riveted butt joint with two cover-plates the pitch of the rivets is 4⅛ in. The rivet holes are $\frac{15}{16}$-in. diameter and the plate is ¾-in. thick. If the ultimate tensile strength of the plate is 58,000 lb. and the shearing strength of the rivet is 40,000 lb., what is the efficiency of the joint? F. H.

A. The efficiency in tension of a double riveted butt joint is given by the relation:

$$Et = (p - d) \times 100 \div p$$

With the dimensions given in your problem then, $Et = (4\frac{1}{8} - \frac{15}{16}) \times 100 \div 4\frac{1}{8} = 77.4$ per cent.

Efficiency in shear is given by:

$$Es = 1.8 \times 3.14 \times d^2 \times Us \times 100 \div 2 \text{ pt } Vt.$$

Substituting the values given, $Es = (1.8 \times 3.14 \times$

$0.88 \times 40{,}000 \times 100) \div (2 \times 4.125 \times 0.75 \times 58{,}000) = 55.4$ per cent.

The net efficiency of the joint is, of course, the smaller of these two values or 55.4 per cent.

Effects of Impurities in Steel

WHAT ARE the objections to a large per cent of sulphur and phosphorus in steel plates?

2. Is there any difference in the manufacture of flange and fire box steel if both have the same physical and chemical contents?

3. What is the difference between cast steel and so-called flowed steel? Also, what is the tensile strength of each?

4. Which resists the action of corrosion the more, iron or steel? Why? J. A. C.

ANSWERS

THE DIFFICULTY with sulphur in steel plates is that it produces red shortness, i. e., it makes the steel brittle at a red heat, therefore, difficult to work. The presence of sulphur has no effect on the strength one way or the other.

Phosphorus in any quantity makes the steel cold short, i. e., brittle under the conditions in which it will be used. A moderate amount of phosphorus does, however, increase the tensile strength of the steel. One-tenth of 1 per cent increase in the phosphorus adds about 890 lb. tensile strength per square inch for acid open hearth steel and about 1050 lb. per square inch for basic steel.

2. There is no difference in the methods of manufacture of flange and firebox steel. They are both open hearth products and the difference is secured by the difference in the charge put into the furnace. Flange steel as specified by the American Society for Testing Materials has from 0.3 to 0.6 manganese, not over 0.05 of sulphur, a tensile strength of 55,000 to 65,000 lb. per sq. in. elongation at fracture in 8 in. of 25 per cent. For acid process steel, the phosphorus is to be not over 0.06 and for basic steel not over 0.04.

Firebox steel has slightly different characteristics, the object being to get a slightly softer steel. Manganese is from 0.3 to 0.5 sulphur, not over 0.04 tensile strength 52,000 to 62,000. Elongation 26 per cent, phosphorus not over 0.04. The two grades run close together but there is sufficient difference in the characteristics so that the steel people have thought it worth while to make distinction.

3. Cast steel is a term variously used. The original name was applied to what is now more frequently known as crucible steel. This is a steel made in crucibles by the heating of either blister steel or refined wrought iron with a carbonaceous material. Bone charcoal is often used. These crucibles are covered and heated for a long period at moderate heat, the carbon being absorbed to a degree by the metal. It gives an exceedingly uniform product.

Cast steel is the name now frequently applied to steel produced by the open hearth process and cast into ingots in moles. It has practically the same characteristics as firebox steel but as commercially applied, its phosphorus, sulphur and manganese content may vary rather widely and the tensile strength may be almost anything from 45,000 to 67,000.

The term flowed steel is one which we do not find in common use. There is a German term "fluss stahl" which is applied to an open hearth steel having a high carbon content and a strength of 71,000 lb. per square inch.

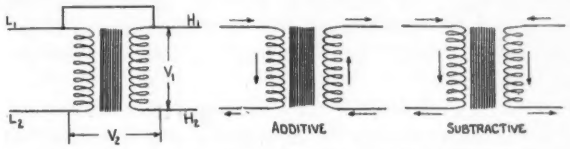
4. Much difference of opinion has been expressed as to the resistance to corrosion of steel and wrought iron. Evidence has been presented in favor of each material by its partisans and tests have been made which seem to show that under like laboratory conditions steel pipe stands up rather better than wrought iron pipe.

For practical working conditions, however, the wrought iron pipe people seem to have the better of the argument so far as records of durability are concerned but this may be due to the fact that wrought iron pipe has been in use longer than steel pipe. Explanations of why one or the other is more durable vary with the man who is making the argument and we do not believe that any really scientific explanation why either one or the other should be more durable has as yet been produced.

Subtractive and Additive Polarity

WILL YOU kindly explain the difference between subtractive and additive polarity as applied to transformer practice? R. C. C.

A. Take a single phase transformer having two high and two low voltage terminals. Connect one high voltage terminal to the adjacent low voltage and apply a potential, V_1 across the two high voltage terminals, as indicated in the accompanying diagram. If the voltage, V_2, across the unconnected high and low voltage terminals is less than



TRANSFORMER WINDINGS TO GIVE SUBTRACTIVE AND ADDITIVE POLARITY

the voltage applied across the high voltage terminals, the polarity is subtractive and, if greater, it is additive.

Polarity standards recommended by the National Electric Light Association are that "Subtractive polarity shall be standard for all single phase transformers, except for transformers of voltage ratings of 7500 v. and below and in sizes 200 kv.a. and less, in which classes the polarity shall be additive."

Polarity is determined by the direction of the windings of the primary and secondary coils. If current flows in opposite directions in the two coils, the polarity is additive and if in the same direction the polarity is subtractive.

Practically there is no difference in the operation of two transformers, one wired for subtractive and the other for additive polarity. The distinction is of value purely in simplifying the connections. All transformers that are to be connected up in parallel should have the same polarity. In this case similarly located terminals should be connected together.

Mud Drum Must Be Free from Setting

IF THE mud drum of a B. & W. boiler rests upon the brick work, what harm will result? When is this condition most noticeable? E. E. C.

A. If the mud drum of a B. & W. boiler rests upon the brick work, it will have the weight of the boiler upon the brick work when heated, caused by the expansion of the headers and nipples. These parts will sustain the weight of the rear of the boiler, causing the nipples to leak in the headers and saddle piece, resulting in serious leaks. The mud drum should never rest on the brick work.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Business in Presidential Years

Business in 1924 may be below normal. If so, it will not be because a president is to be elected. It may be a year of real prosperity but not because it is a presidential year.

Except the reactionary 1920, there have been five presidential years since 1880 when business was above normal and five presidential years when business was below normal. In all these years, except 1896, the business trend continued upward or downward unaffected by the period of election.

In 1880 business was approximately 10 per cent above normal. In 1884 business started at 10 per cent below normal and continued to recede until it reached 20 per cent by the middle of 1885. In 1888 business was 8 per cent above normal. In 1892 business was 10 per cent above normal. In 1896 business was 12 per cent below normal. In 1900 business was 5 per cent below normal. In 1904 business was 2 per cent below normal. In 1908 business was 3 per cent below normal. In 1912 business was 6 per cent above normal. In 1916 business was 15 per cent above normal. In 1920 business was reactionary—not comparable.

Five lean years—five fat years—one reactionary year. It would seem that the old superstition that a presidential year means poor business is a myth.

Play Down the Investigations

One of the gratifying developments of the past few weeks is the order given to Washington newspaper correspondents to "play down the investigations."

That order should have been given a long time ago. We should never have heard much of the piffle and balderdash that has filled the newspapers during the past several months, for a great deal of it was just naked lies; and lies are terrible things. The real danger in having them around is that you, otherwise sane, are liable to repeat them, thus sending them on their destructive way.

Lies are humming birds with eagles' wings and the voice of a Big Bertha. They have caused more trouble in these almost United States than all the cyclones, tornadoes, yellow fever, gout, chinch bugs, smut, rust, ticks, fleas, scorpions, indigestion, boll weevils, rattle snakes, spring fever, blizzards and floods than we have ever known or ever will know until the universe closes up shop.

Investigations and Citizens

Some new investigations will start and continue through the summer. Practically all of the old ones will be continued. Teapot Dome will boil as long as the radical element can keep a fire under it. The Revenue Bureau, Shipping Board, Bureau of Engraving, Veteran's Bureau, Aircraft, Attorney General's office, Prohibition, and others will come in for their share of trouble. We predict that the insurgents will make this year's campaign contributions a subject for investigation. The principal object of it all is to shatter confidence and faith in the government to the extent that enough votes may be pulled away from the two old parties to elect the radical element to office this fall.

And this country will be safe from investigations and scandal only when it realizes that no one man—no one department—no one party is to blame for present conditions. There will be investigations until the realization comes that *we*, the American people, merely see our reflection in Washington. The Washington situation is merely typical of nation wide conditions.

The Red agitator proclaims openly. "To hell with all government, all churches, all synagogues." Violators of law, whether it be prohibition, speed laws, child labor, or other laws, say by their acts which speak louder than words: "To hell with all government and all laws which are contrary to our personal desires or to the gratification of our individual pleasures."

He who violates the law, in any place, merely to satisfy his personal appetite or profit, should not blame him who, in Washington, breaks a law to the profit of himself. Those who have broken faith with the Constitution of the United States by conniving to override its provisions are in no position to censure the man who breaks his oath of office and sacred trust to sell or buy some oil.

Destruction Exceeds Production

Originally the United States had 800,000,000 acres of forest land. Today less than one-half that area can be called "timber land" and only about 1/6, or 137,000,000 acres remains virgin or uncut forests.

More than 30,000 fires occur in the forests of this country every year. They result in the devastation of between three and four millions of acres of timber annually. Something over 7500 of these forest fires are caused by carelessness or vandalism.

Timber is being used or destroyed in the United States four times as fast as it is growing.

Prosperity Shown in Hugh Freight Movement

More cars were loaded with revenue freight during the first thirteen weeks of this year (January 1 to March 29) than any corresponding period on record. The total for the 13 weeks was 11,587,274 cars.

This was an increase of 270,534 cars over the corresponding period in 1923, which had set a high record in itself. Compared with 1922, it was an increase of 1,686,137 cars.

Spending More Than We Earn

Total wealth of the United States at the close of 1922 was $320,803,862,000. This is an increase of 72 per cent over the total wealth as of 1912. The increase therefore was 7.2 per cent annually.

The total net public debt, not considering the war or national debt, increased at the rate of 12.8 per cent a year during the same period.

Increasing wealth at the rate of 7.2 per cent and indebtedness at the rate of 12.8 per cent is not so good. It means that we have, during the past 10 yr., spent over $105 for every $100 earned. Uncle Sam, watch your step!

We Need Another "Big Stick"

Back in the days of 1870—1900 big capitalists enjoyed a dominant position, and their exploitation reached its zenith. Child labor was employed; wages were low; restraint of trade was practiced; monopolies were formed and trusts created; prices were unnecessarily advanced and lobbyists were employed to intimidate or bribe legislators and to ward off adverse legislation.

That condition continued until there came a man possessed at once of the three attributes necessary to combat such a combine: personality, fearlessness, clearheadedness.

The manner in which he wielded the "Big Stick" and the way he enforced the Sherman Anti-Trust law should have served as a caution to all those bent upon the establishment of any policy detrimental to the public. Through personality he won his place; fearlessly he attacked and overcame the powerful moneyed interests; by clear thinking he made a return to the then existing conditions impossible.

During the recent war opportunity placed big labor leaders in the saddle. We are now having restraint of trade, monopoly, advanced prices and exploitation. Another wielder of the "Big Stick" is needed.

Taxes or Dividends

At the present time the railroads of the United States are paying out more in taxes than they are in dividends. The $301,003,227 they contributed to the public treasury in 1922 is 11 per cent greater than the $271,576,000 they turned over to their security holders in interest and dividends. In the last ten years, railroad tax payments have increased 135 per cent and dividends decreased 16 per cent.

The great bulk of present-day railroad effort results in direct contributions to the general public's welfare rather than in corporation profits. The railroads are really working harder for the general public than they are for their owners.

Railroads have been likened to the arteries in the human body. It is an excellent comparison. Without arteries we would cease to be. Without railroads, or adequate transportation, prosperity would cease to be.

Railroads should be protected from unwise legislation. When a few senators propose higher taxation, lower rates, or other detrimental laws they should receive a demonstration of aroused public opinion.

High Building Costs

Report of the National Industrial Conference Board states that bricklayers in fifty cities are paid $1.25 an hour; plasterers in 44 cities, masons in 28 cities and lathers in 12, receive a similar wage. The Board's survey reveals uniformly high wage rates for practically all classes of building trades workers and the board attributes to this fact the doubling of building costs in the last 10 yr. "during the country's greatest construction boom."

No reason for the high labor cost is given, presumably because it is so well understood. Low output, shortage of workers and high wages have not been sufficient to prevent a remarkable building boom, but have been instrumental in restricting the erection of homes needed for workingmen's families.

As the need for more buildings becomes less pressing we are wondering if these influences will not materially shorten the life of the boom. E. M. Statler has announced that the proposed Statler Hotel in Boston will not be erected until prices of building labor and materials register a material reduction. Continually pyramiding costs made it evident that a profit could not be made on a hotel built under present conditions. Coincident with decreased demand, builders of office buildings, apartment houses, and dwellings may reach a like decision.

It is estimated by the Architectural Forum, a leading trade journal in that field, that during 1924 expenditures for new buildings in the United States will be in excess of $5,560,000,000. It is of interest to know that the middle states group leads the six sections into which the country is divided. The North Atlantic states rank second in this estimate, being about 33 per cent below that accorded the Middle States.

This estimate gives schools the lead over all other single divisions, which seems most gratifying. It is estimated that over $802,000,000 will be expended on schools this year. Hotels are second with a sum exceeding $635,000,000. Apartments rank third, being accorded $568,000,000.

The economic situation in this country today (and the possible trend of things) may be summarized as follows:

We shall have successive periods of excess production of goods, due to industrial miscalculations. These will be followed by periods of digestion. It is clear now that 1923 was, generally speaking, a year of over-production and that most of this year will be a period of digestion.

IF YOU run an excuse factory, sell out and take up a line that pays. One half the gray matter expended on the generation of an excuse would have prevented the error every time.

ACCORDING TO FIGURES compiled by the National Industrial Conference Board, there was a further recession in manufacturing activity during the month of April, 1924. Although there was no significant change in earnings, employment declined 2.5 per cent from the preceding month and the average hours of work per wage earner fell off nearly half an hour. From a total of approximately 1700 plants which furnished data to the Board, ten reported a total shut down in April and 150 others were working less than normal hours per week.

Average hourly earnings of all wage earners dropped very slightly from 56.1 cents in March, to 56.0 cents in April. Fifteen industries reported decreases, in seven there were increases and one showed no change.

Average weeking earnings of all wage earners declined from $26.89 in March to $26.67 in April. In sixteen industries weekly earnings decreased, in six they increased and in one there was no change.

An upward movement is noticeable in "real" earnings, or the purchasing value of money earnings, due to the sharp drop in the cost of living index number between March and April. The index number of "real" hourly earnings advanced to 142, and the "real" weekly earnings of the wage earners employed in April stood 32 per cent higher than in July, 1914.

EDITORIAL COMMENT

Automatic Combustion Control Should Be Studied Without Prejudice

Although considerable progress has been made in applying mechanical methods to the control of combustion, every indication points to the fact that this rather baffling problem is far from its ultimate solution.

Two main reasons may be cited for the comparatively slow progress which has been made in this field. The first of these, and one of no small magnitude, is the attitude of plant operators, and the second is the lack of consideration of the problem in its entirety.

In commenting on the general problems of combustion control before a recent section meeting of the A. S. M. E. in New York, R. J. S. Pigott called attention to these two important essentials.

Two operating viewpoints which tend to destroy the performance of any regulation system were pointed out by Mr. Pigott. First, the general disbelief that any mechanical contraption can possibly regulate a fire as well as an experienced fireman, and second, expecting the apparatus to do things without attention or supervision that do not lie in its power.

Mr. Pigott in his paper, which is abstracted in this issue, suggests that the problem of regulation should be approached by the station designer much in the same way as heat balance is approached. It should, in other words, be considered as part of the design and the regulation system should function as a completely synchronized group of devices and not as a number of independent units.

There may be many engineers who will not agree with all of Mr. Pigott's conclusions. Naturally that is to be expected, in a problem as complex as automatic combustion control. The points to keep in mind, however, are that the attitude of operators can defeat the purpose of the control scheme and that all of the fundamentals of combustion must be understood by the designer of a system.

Mechanical aids to combustion control, with the attendant centralization of control, offer one of the most fertile fields for power plant improvement. It requires further experimentation and application. The power plant men of the country can aid in this development by giving their whole hearted support and encouragement to it, or, on the other hand, the development will be retarded if the men in the plants allow prejudices and the "it can't be done" viewpoints to predominate in their consideration and use of such control schemes.

Business Training and Ethics

Let's get our definitions straight first, so that we'll be thinking alike. For business, let's take the broad meaning — production, distribution and selling of raw materials and of partly or fully finished articles used by mankind. That, then, covers all activities of human beings except personal service occupations. Next, as training, let's include all preparation for business—physical, mental and moral, whether made before or during one's active business career. In this is exercise, schooling above the primary grades, reading, church attendance, in fact, whatever affects physical, mental or moral fitness for business activity. In ethics, let's include all standards of right action as to activities in one's daily work.

Now we have succeeded in including practically everything we do except our contact with the family and social friends. Maybe it would be well to apply, even in these relations, the same care in preparation and standards of action that we find wise in business relations.

In some earlier days, business was regarded as a heartless affair. Compare "let the buyer beware" with the motto of a modern commercial establishment, "the customer is always right." Evidently the latter is as unreasonable as the former, even if more ethical; but the difference shows what a change has come about in standards. Modern business, at its best, realizes that its object should be to serve—a transaction which benefits both parties, not an overreaching of either by the other.

Buyer and seller should both be better off after a trade. Both employer and employe should benefit by their partnership in industry. Each should be able to say "I have given full value for what I received."

Has business as defined above, reached this condition? If not, what is lacking? What preparation do we need that the business of the world may be done in accordance with these ethical standards?

Fundamental needs are, obviously, character, which ensures right, dependable action; intelligence, including practical common sense, which will avoid rainbow chasing with all its fine intent and disastrous results; power of accomplishment, which includes good judgment, steadfastness of purpose and endurance under difficult conditions. Evidently these are personal attributes which must be developed in the individuals of a business organization, whether farming, manufacturing or merchandising, if they are to be a part of the organization policy.

Executives, including managers of power plant industries, must be leaders in their organizations, if they are to succeed. Largely it is a part of their job to see that those organizations have ethical standards and that training of individuals is such as to ensure action according to those standards.

You will wonder why this dissertation in a technical journal. First, we believe that our readers are men who are eager to do the best they can for themselves and their fellows. Second, we have been reading the prospectus of Antioch College at Yellow Springs, Ohio, where a course for young people who are fitting for business, including engineering, is being developed; and the object of that course is to train men who will carry into business just the fundamentals that we have outlined as essential. We have no partisanship for that college but we believe the

adoption of its code by everybody engaged in business would be a long step toward getting the business of the world on a sound and enduring basis and doing away with booms and depressions.

Here's the Antioch Business Code, in substance: Sound business is service which benefits all parties concerned. To take profit without contributing to essential welfare; to take excessive profit; to debase standards for profit; to use methods not inspired by good will and fair dealing; these are dishonor. Whenever I make or sell a product or render a business service, it must be my best possible contribution to human well-being.

Accident Prevention

Nowhere is the saying that "a safe workman is the best safety device" more true than in the operation of a power plant. Surveys extending over a number of years in various industries show conclusively that only 25 to 50 per cent of all industrial accidents can be prevented through mechanical means. That is, the safe-guarding of machinery and equipment can never completely protect the workman and therefore other agencies must be brought into play.

With the above percentages in mind the indictment must be made that from 75 to 50 per cent of all accidents are due to the ignorance or carelessness of those who are injured or their associates. Those injuries which are the direct result of ignorance must be charged up against the management, for it indicates that proper instruction has not been given. This instruction, having been given, however, the responsibility rests with the workman.

Carelessness is as much a frame of mind as it is a bodily habit and it has just begun to dawn upon us what causes that frame of mind and how it can be changed. The installation of mechanical devices alone will not effect the desired result but their combination with educative methods and the bolstering up of morale will result in reducing accidents to the minimum.

Every employe should know that a prequisite to promotion is not only the thorough understanding and constant practice of the safety rules pertaining to his own job, but also an understanding of the safety rules of the job to which he aspires. It is up to the management to initiate the safety movement and then insist upon having the full cooperation of each employe.

Engineers as Missionaries

What is the underlying motive of missionary work? For the man or woman who is isolated in far countries, or the one who devotes time and energy to the dark spots of our own land, the fundamental wish is to help human beings to live better and happier lives. Money getting has no place in the plans.

For the engineer, piling up a fortune is usually not considered. Service to industry and thus to mankind is the impelling motive. More and more this is coming to be recognized as the right attitude for all business but for engineers who have achieved success it has always been the ideal. In fact most men who are ranked as successful have striven first of all to be useful and helpful; fame or material welfare has come as an accompaniment of success, not because it was the objective aimed at.

What excitement or experience that money can buy is to be compared to the satisfaction of having helped one or many fellow men to happier living? Too much the thought of this country and of the world has dwelt on "how can we get more so as to have more to spend?" We need to change that and put the emphasis on "how can we get the most satisfaction out of life?"

Engineers are accustomed to dealing with facts and facing logical consequences. Their most useful "serving men" are how and why. The application now is why has the world lost its head in the mad struggle for gain to the exclusion of the spirit of helpfulness? And how can engineers be of most help in getting the world back to sanity?

One great educator has said that you can teach facts but character is caught from example and association. The world has been greatly helped in a material way by the facts and methods which engineers have taught it. What is needed now is that the world shall catch by association and from example the spirit of service which is the foundation of the engineer's work. If the engineering profession continues, even more aggressively, to put forth its efforts to be of service to its fellow men as man to man, as organization to organization and as citizens to their government, and if engineers advocate helpfulness as against mere getting as the standard by which success is to be judged, it will be a leaven which in time will permeate the whole mass.

If developments prove that a severe lesson of hardship is the only way that the world can be brought to its senses, then engineers should be ready to take the lead in rebuilding industry and business on a basis of rendering the best service to mankind. Honesty, sincerity, helpfulness—the engineer may well be proud to be a missionary for these standards to a world which is beset with corruption, graft, intrigue and self seeking.

The Automatic Station as a Factor in Conservation

In considering the conservation of our natural resources, the idea of utilizing the power available in the small rivers and streams throughout the country has appealed to many engineers. The amount of power available at any particular stream may be small but when it is considered that there are thousands of possible sites, it is easily seen that their development would add materially to the nations available power supply. The principal obstacle in the way of carrying out this idea has been the expense of maintaining a skilled operator at each plant.

With the advent of the automatic stations, however, the aspect of the problem has changed and its solution simplified. Such stations, being entirely automatic, do not require the constant attendance of an operator, and as a consequence the cost of maintenance is such as to permit of a fair return on the investment. These small plants, ranging in size from say 25 or 50 to a few hundred horsepower, therefore have a definite place in the general scheme of power development and should receive a considerable amount of attention from an engineering standpoint.

In this issue we describe an installation of 148 kw. capacity. Not much of importance when compared with Niagara Falls or Muscle Shoals with respect to size, but as a type, it is important, and its development must be regarded as another step towards the efficient conservation of natural resources.

150,000-Kw. Plant for the Tri-Cities

Main Turbine Unit to Be Bled at Four Stages, Three for Stage Feed Water Heating and One for an Evaporator

SIX MILES from the business center of Davenport, Iowa, there is being constructed a central station which will ultimately be rated at 150,000 kw. The boiler pressure will be 400 lb. and steam will be bled from the turbine at four stages, three for the purpose of feed water heating and one for the use of a make-up feed water evaporator. Bled steam will also be tried out for preheating the air used for combustion.

Davenport is one of the Tri-Cities, Rock Island and Moline being the other two, the two last named cities being located on the Illinois side of the Mississippi River. The new station will be located on the river and directly opposite the business district of Moline. A number of factors influenced the selection of this site. It is closer to the load center than is any other available site. The new plant as located will be on the Clinton, Davenport and Muscatine Ry. which is an interurban system operated by the United Light and Power Co., which owns and operates the new station.

Location of the station on this interurban line gives a further advantage in that the railway company participates in a division of freight rates. On the site selected, the rock is close to the grade line, entirely eliminating the necessity for costly foundations. A gradual slope exists in the rock which eliminates expensive excavation for condenser water intake and discharge.

No Trouble Expected from Silt

This site is also particularly free from ice jams in the winter time and there is practically no deposit of silt at this point, the rock for a considerable distance on either side of the site being entirely free of silt. Grades are such that it will be possible to bring standard gage railroad cars into the basement for removing ash, as is shown by the

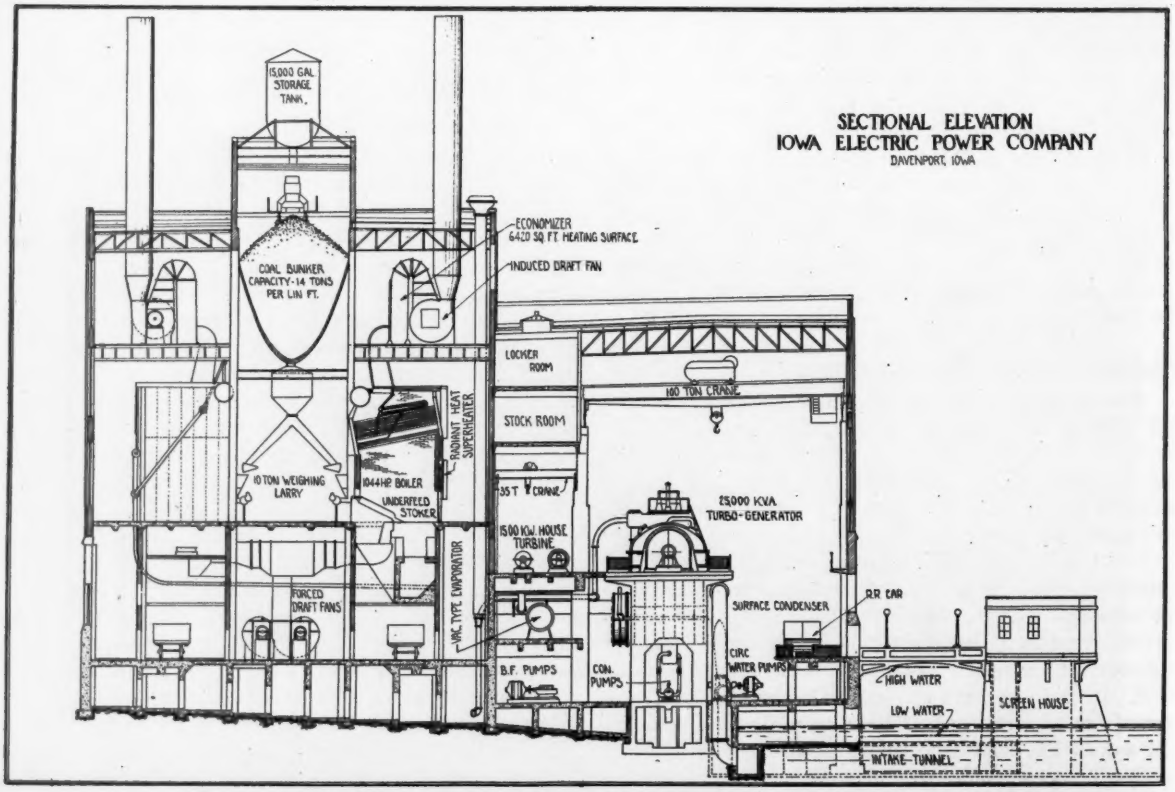


FIG. 1. CROSS SECTION SHOWING COMPARATIVE SIMPLICITY OF OBTAINING FOUNDATION FOOTING

cross section of the plant. This new station is being built on a site which contains 100 acres, thus assuring a plant expansion to meet any possible growth of the community.

Many interesting details of design and arrangement will be noted by a study of the cross section of this plant. The screen houses are separate from the main station and are located at the end of a wing dam so that the condenser discharge will be on the down stream side of the dam and the intake above the dam. The turbines are being set lengthwise of the generator room. A 100-T. Whiting crane will travel the full length of the generating room, which is arranged with open spaces in the floor so that this crane can also handle heavy parts on the floor below.

Located between the boiler and generator rooms is a long but comparatively narrow part of the building which is subdivided into five elevations. In the basement, or at the lowest elevation, will be located the feed pumps. Directly above, at the second elevation, will be located the vacuum type evaporator. On the third elevation will be located the 1500-kw. house turbine and some auxiliary equipment. This space at the third level will be equipped with a 35-T. electric traveling crane. The space at the fourth level is designated as a stock room and above that, at the fifth level, will be found a locker room for the employes.

Forced draft fans are to be located in the basement of the boiler room. They will discharge into a common duct which leads both ways to the boilers which are to be set on both sides of a central firing aisle.

Water Storage Tank Above Roof

Each boiler is rated at 1044 hp. and will be fired by an under-feed stoker. Superheaters and economizers are to be provided. Coal is to be stored in a suspended bunker which will be located over the main firing aisle. The capacity of this bunker is estimated at 14 T. per lineal foot. Coal distribution to the stoker hoppers is to be effected by means of a 10-T. weighing larry. A 15,000-gal. water storage tank will be placed above the coal bunker. Each boiler is to be served by an induced draft fan and a separate steel stack.

This being a plant of only moderate size, it was not desirable to select steam and other conditions or equipment which might necessitate substantial changes. Steam pressure will be 400 lb. at the throttle, with a temperature of practically 700 deg. F. over a wide range of boiler rating. A combination of radiant and convection superheater was chosen to maintain a temperature curve as flat as possible. Inasmuch as but one unit will be operated for some time, it will be necessary to follow the load curve and vary boiler ratings, rather than change the number of boilers in service.

All auxiliaries are motor-driven, feed water being heated by means of stage heaters, extracting at four points, together with high-pressure economizer. The use of stage heaters beyond an economizer is perhaps rather unusual, but well warranted from the economic standpoint. Instead of using an air heater beyond the economizers, the air to the stokers will be preheated by bleeding the turbine. Only one pre-heater is being installed and the others will be installed if tests prove that they are warranted. A greater ratio of economizer surface than that selected, which is 65 per cent, would possibly have been justified. It was decided, however, to err on the side of putting in too little

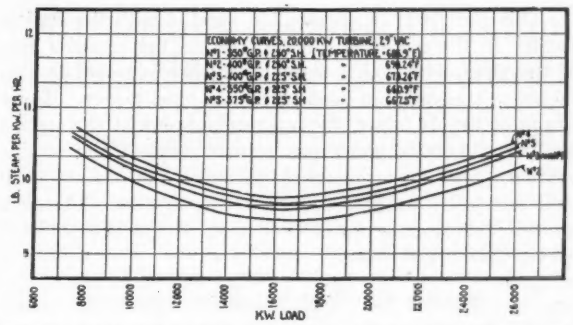


FIG. 2. ECONOMY CURVES FOR THE MAIN GENERATING UNIT

rather than too much economizer surface, as a decreasing rather than an increasing coal price is anticipated.

Boilers are being encased in such a way as to form air ducts, these ducts leading to the fan intakes. All of the auxiliaries are normally to be operated off the main bus, giving a maximum opportunity to bleed steam for feed water heating. The house service turbine will be connected to the main bus through reverse current relays, the generator operating as a synchronous condenser and the turbine operating at full speed. It is arranged so as to operate without requiring steam for cooling.

Study was made of the comparative efficiencies of variable speed alternating current motors, direct current motors and two separate motors of different speeds for driving the induced and forced draft fans. Each induced draft fan is to be equipped with one 165 hp. and one 40-hp. slip-ring induction motor and each forced draft fan with one 100-hp. and one 25-hp. slip-ring induction motor. The boilers will normally be operated at a rating which will load the small motor on each of these fans to just about its rating, so that the efficiency will actually be higher than with either of the other arrangements and the cost is approximately $10,000 less.

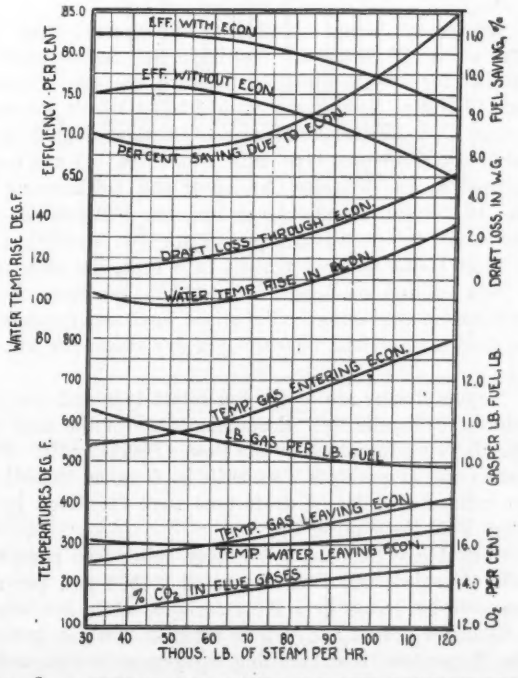

EFF. WITH ECON.
EFF. WITHOUT ECON.
PER CENT SAVING DUE TO ECON.
DRAFT LOSS THROUGH ECON.
WATER TEMP. RISE IN ECON.
TEMP. GAS ENTERING ECON.
LB. GAS PER LB. FUEL
TEMP. GAS LEAVING ECON.
TEMP. WATER LEAVING ECON.
% CO2 IN FLUE GASES
EFFICIENCY - PER CENT
WATER TEMP. RISE DEG. F.
TEMPERATURES DEG. F.
FUEL SAVING, %
DRAFT LOSS, IN W.G.
GAS PER LB. FUEL, LB.
CO2 PER CENT
THOUS. LB. OF STEAM PER HR.

FIG. 3. PERFORMANCE CURVES FOR THE ECONOMIZERS

This plant will be operated in parallel with the station located in the center of Moline, Ill., on the opposite side of the river, with which plant it will be connected by two 66,000-v. transmission lines carried on steel towers. There are to be two 15,000-v. step-up transformers at the station and two 15,000-v. step-down transformers at the Moline station. Owing to the lower efficiency, the Moline plant will carry the wattless energy of the system. This had considerable bearing on the selection of the 100 per cent power factor generator.

Switch House is Separate Building

The switch house is to be on the boiler room side of the building and separated from the main plant proper. In it are to be located the 13-000-v. bus structure and the main control board. The switch house will have a similar relation to the boiler room that the screen house has to the turbine room, except that it will be a two-story structure. It will be connected with the boiler room by a

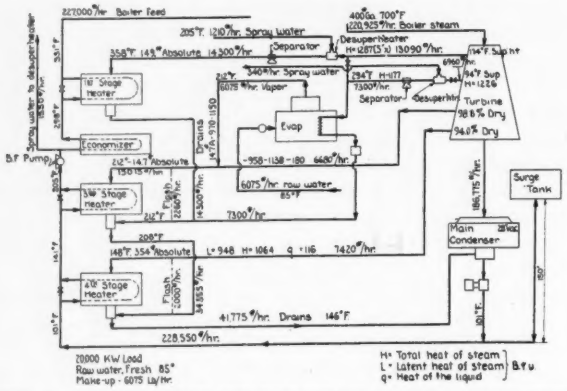


FIG. 4. APPROXIMATE HEAT DIAGRAM FOR THE STAGE FEED WATER HEATERS AND THE EVAPORATOR

bridge, similar to the one connecting with the screen house.

Equipment being installed at the present time consists of a 25,000-kv.a. Westinghouse turbo-generator, designed for 400 lb. operating pressure, 250 deg. F. superheat, 13,200 v., 3-phase and with a 250-v. direct connected exciter. The surface condenser is rated at 30,000 sq. ft. and is of the two pass type, with 1-in. tubes. It was manufactured by the Wheeler Condenser and Engineering Co. Two 16,000 gal. circulating pumps, two 600-gal. hot well pumps and two rado-jet air pumps are also provided.

Four Heine boilers, straight tube type, are each rated at 1044 hp. and are designed for 440 lb. pressure. Foster combination convection and radiant heat superheaters are designed to superheat 60,000 lb. of dry steam per hr., 250 deg. F.

Taylor stokers are of the ten retort type and are to be operated hydraulically. Economizers are of the steel tube type and were furnished by the Power Specialty Co. Stage heaters and evaporators were built by Griscom-Russell and the induced and forced draft fans were furnished by the Green Fuel Economizer Co.

Two Allis-Chalmers, seven stage boiler feed pumps are to be provided. One will be rated at 500 gal. per min. and is to be driven by a Kerr turbine, while the other is to be motor driven and will be rated at 300 gal. per min. The Brownhoist coal handling equipment is designed for 300 T. per hr.

One 1500-kw. Westinghouse turbo-generator will be provided as a house turbine unit. It is designed for 480 v., 3-phase and 60 cycles. This unit is non-condensing and in normal operation will receive no steam, operating as a synchronous condenser. In case of a disturbance of the main bus, the house-service transformer will be disconnected by reverse power relays and the house-service turbine will then pick up the station auxiliary load.

Design and construction of the entire station, including the building, is being carried on by the engineering department of the United Light and Railways Co.

Klydonograph Records Voltage Surges on Transmission Lines

ALTHOUGH it has a rather formidable name, the Klydonograph, an instrument recently developed by J. F. Peters, of the Westinghouse Electric & Mfg. Co., is a

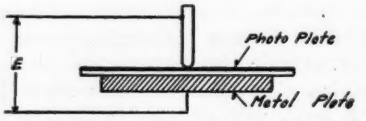


FIG. 1. SIMPLEST FORM OF THE KLYDONOGRAPH

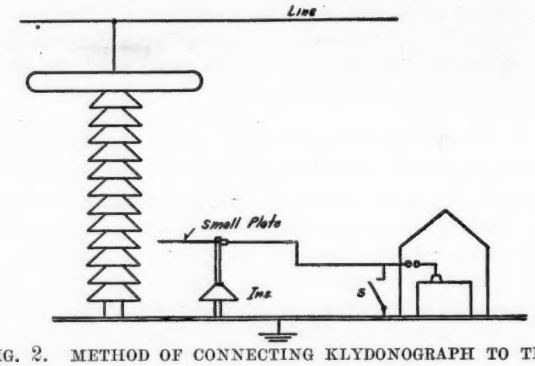


FIG. 2. METHOD OF CONNECTING KLYDONOGRAPH TO THE LINE

simple device for recording abnormal voltages on transmission lines. With this instrument, a graphic record of voltage surges of extremely short duration can be obtained,

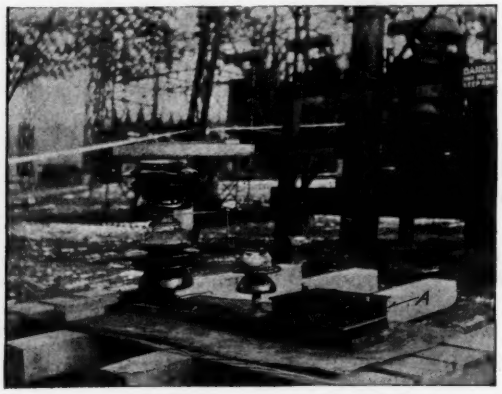


FIG. 3. TEMPORARY SET-UP USED FOR SHORT CIRCUIT TESTS OF A 22,000-V. SYSTEM

giving their polarity, magnitude, steepness of application, etc.

An old principle first observed in 1777 by Dr. Lichtenburg is used in the new instrument. Dr. Lichtenburg found that, if he discharged a condenser, such as a Leyden jar, across a spark gap onto a terminal in contact with an insulating plate placed between this terminal and a ground plate, and then removed the terminal and sprinkled powder on the plate the powder would arrange itself in a figure that had a very peculiar appearance. In 1888, J. Brown and E. Trouvelot found that with the insulation plate replaced by a sensitized photographic plate, the emulsion in contact with the terminal, figures similar to those of Lichtenburg were created and appeared upon development.

In its simplest form the Klydonograph looks like the diagram shown as Fig. 1. The photographic plate, of course, must be in a dark box. If a voltage is impressed between the terminal and the ground plate, as at E, on developing the photographic plate, figures will appear that will give pertinent information concerning the nature of

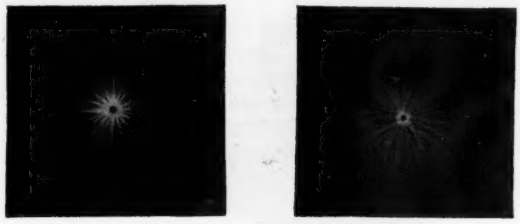


FIG. 4. AT THE LEFT IS A PHOTOGRAPH OF A POSITIVE SURGE WITH AN ABRUPT FRONT AND AT RIGHT A NEGATIVE SURGE WITH ABRUPT FRONT

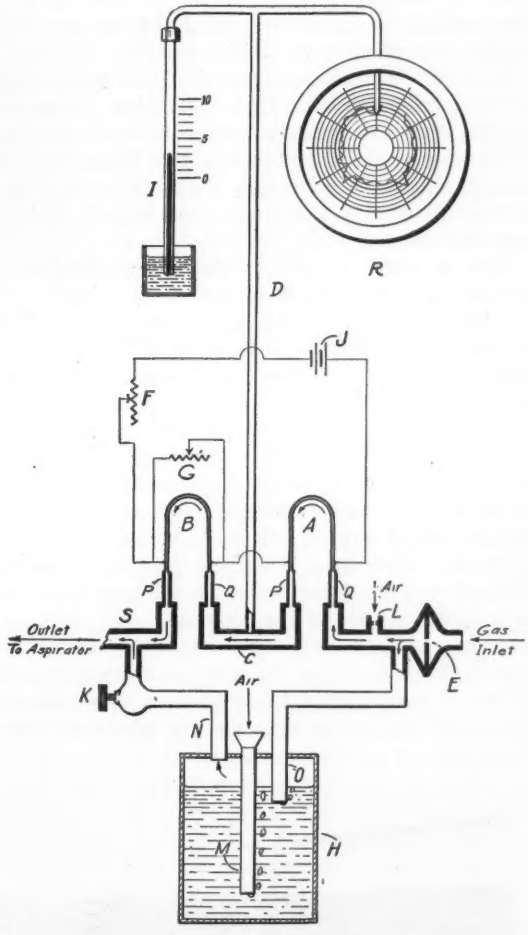
the voltage impressed. If, for instance, the voltage is in the form of a surge that is unidirectional, with a sheer front or a tapered front, the figure of the photographic plate will differentiate between the tapered front and the abrupt front and it will also indicate whether the surge was of positive or negative polarity. The diameters of the figures also give a measure of the magnitude of the surges although the positive and negative figures have quite different calibrations, the figure for the positive surge being considerably larger than that for the negative surge of the same magnitude.

For practical application, the instrument is made continuously operative and is capable of recording the exact time of the occurence of the disturbance. The instrument makes use of a 10 and 12-in. plate in a special plate holder and the moving parts are driven by a clock that makes one complete revolution in 24 hr. Figure 2 shows a method of connecting the Klydonograph to the line. Since this instrument is practically a zero current device, it is possible to connect it to the line electrostatically. This makes it possible to connect to a high voltage line without introducing an insulation hazard. With the Klydonograph connected as shown in this figure, the figures produced give the magnitude and polarity of the surges.

STONE AND WEBSTER, INC., have been awarded the contract at approximately $1,250,000 for the construction of a steam power plant on Terminal Island for the Southern California Edison Co. The structure will be of reinforced concrete with ground dimensions of 270 ft. square.

Electrically Heated Platinum Tubes Used in CO_2 Recorder

IN THE development of a new CO recorder by the Uehling Instrument Co., of Paterson, N. J., a novel scheme is employed to secure the motive power for actuating the recorder by burning the combustible in electrically heated platinum tubes. A and B are the platinum tubes of small bore, through which the gas sample flows continuously. The gas enters through the inlet opening, E, thence into the platinum tube, A. If CO or any other combustible gas is present, it burns within the heated tube, A, and increases the tube's temperature more or less, depending upon the amount of combustible present. Then the burnt-out gas flows through the platinum tube, B, and out of the latter under a fixed suction. As tube A becomes hotter, the gas flowing through it expands and conse-



VACCUM IN CHAMBER C CAUSED BY BURNING OF CO IN TUBE A ACTUATES RECORDER

quently less gas enters chamber C. The outlet suction does not vary, hence a decreasing flow of gas through tube A results in a greater partial vacuum in chamber C. Thus the varying suction in chamber C becomes a measure of the heat units in the gas and by connecting chamber C with a recording gage, R, by means of tubing, D, the quantity of combustible can be recorded any distance away.

Calibration is in percentage of CO, although if hydrocarbons or hydrogen are present, they will also be recorded in terms of CO of equivalent heat value. It is also feasible to calibrate the instrument in B.t.u. per cu. ft. of gas. An auxiliary indicator, I, is also of value for mounting on the boiler front to serve as the fireman's guide. A leak is provided at L which dilutes the gas with air by a definite small amount so as to insure sufficient oxygen at all times to complete combustion in tube A.

Either direct or alternating current may be employed, the current consumption being about 40 w. The diagram shows the machine operating on a storage battery, J, with a rheostat, F, in series. Even severe voltage variations have no effect on the accuracy of the instrument because both tubes are heated or cooled to the same degree by such changes and it is only a difference of temperature between the two that affects the suction in chamber C. Rheostat G, in shunt with platinum tube B, provides a means for raising or lowering the temperature of tube B a few degrees, which is a simple way of making any slight adjustment required in the initial setting.

When the CO recorder is used with Uehling CO_2 equipment, no suction regulator, H, is required as the standard regulator of the CO_2 recorder insures gas flow to and from the CO recorder at the proper velocity. When used independently of the Uehling CO_2 recorder, however, it is necessary to employ a suction regulator, H, which is simple but effective.

Tube M, which is open to the air, extends into the water almost to the bottom of the vessel. Exactly 6 in. above its lower end is the bottom of pipe O. Part of the gas entering the instrument is bypassed through pipe O, bubbling up through the water in H and escaping through pipe N.

This pipe communicates with an aspirator or main suction through needle valve K. The rate of flow depends upon the setting of K, which does not have to be exact, as long as it is open sufficiently to cause air to bubble from the end of pipe M and gas to bubble from the end of pipe O. Under these conditions, pipe M is completely filled with air, the water level at its submerged end being consequently at atmospheric pressure.

Correspondingly the bottom of pipe O, which is 6 in. above the bottom of pipe M, is under a constant suction of 6 in. of water head. This suction is thus maintained constant all the way back to the first platinum tube, A, regardless of any change in the tension of the gas on the inlet side of the opening E, caused by draft variations or otherwise.

Make-up water may be added weekly through tube M, the exact level of the water being immaterial as long as tube O is submerged. An arrangement similar to that used with standard Uehling CO_2 recorders, is employed for creating the primary fixed suction at S. A steam, air or water aspirator, as preferred, can be supplied.

Pipe Threading Machine Is Portable

A NEW portable pipe threading, cutting-off, and reaming machine has been brought out by the Williams Tool Corporation, Erie, Pa. The principal features are that it is portable, demountable, has a self-contained

DRIVE IS BY MOTOR, BELT OR HAND, AS MAY BE DESIRED

grinder and three drives, motor, belt and hand, built into the machine. A unique feature of the machine is the fact that it can be converted into a power unit in 2½ min., and by using a flexible shaft it will operate hand stocks up to and including 8 in. The weight of the machine complete with motor and all standard parts is 520 lb.

STEEL GIRDER FOR ONE OF TWO 125-T. ELECTRIC TRAVELING CRANES BUILT BY THE WHITING CORP. FOR THE CRAWFORD AVENUE STATION AT CHICAGO. EACH CRANE WILL SPAN 122 FT. 4 IN. AND WILL HAVE A LIFT OF 69 FT. THE WEIGHT OF EACH CRANE WILL BE 375 T.

For driving the machine a 1-hp. motor is mounted on a hinged table in the base and the power is transmitted by belt to the flange driving pulley of machine. The machine can be converted to belt drive, by simply removing the motor belt and driving directly from a line or countershaft. Provision is also made for operating machine by hand. It is only necessary to shift the gears to neutral position when the demountable crank handle can be fitted directly to the worm shaft which is direct connected to the spindle through worm and worm wheel with ball thrust which operates in oil. It is possible to cut right- or left-hand threads on pipe ¼ to 2 in. and on bolts from ⅜ to 1½ in. inclusive. The cutting-off capacity covers the same sizes of pipe and bolts as listed above. The machine will ream the inside and chamfer the outside of pipe, inclusive from ¼ to 2 in. The longest run thread at one chucking is 10½ in.

A special feature of this portable machine is a high speed emery wheel which is mounted on the pulley shaft at the rear of machine and driven direct from the motor. The wheel is set at such a height above the floor as to be most convenient to the operator. The wheel runs about 1100 r.p.m. It is 6 in. in diameter with ¾-in. face, of a proper grade for general grinding purposes.

News Notes

HOWARD E. MURPHY has again joined Stone & Webster, Inc., having taken a position as engineer in its Electrical Division. Mr. Murphy was for many years connected with the Construction Department of this organization, but more recently has been associated with the Luminous Unit Co., of St. Louis, Mo., as illuminating engineer and later as district manager of its Boston and Chicago offices.

GROSS EARNINGS of the Westinghouse Electric & Manufacturing Co. for the year ending March 31, 1924, amounted to $154,412,918, which exceed those of any previous year in the history of the company, except the year ending March 31, 1919. Value of unfilled orders at the close of the fiscal year was $63,738,702, which compares with last year's figures of $61,914,237.

PRESENT POWER PLANT equipment of the La Junta, Colorado, car and locomotive repair shops of the Atchison, Topeka & Santa Fe R. R. is inadequate and plans are now being considered for increasing the plant rating. At present the equipment consists of four 300 hp. and one 250 hp. hand fired B. & W. boilers and one 375 kv.a. Westinghouse turbine. It is expected that one 500 hp. B. & W. boiler and a 500 kv.a. turbine will be added. The plant is also being surveyed to determine whether pulverized coal equipment or stokers will be installed. As the present boilers are set quite low it will be necessary to raise them if stokers are installed, while on the other hand, if bunkers and pulverizers are installed the roof of the present boiler house will have to be raised. E. D. C. Miller is the chief engineer and H. C. Stevens the chief operating engineer.

ECONOMY FUSE & MANUFACTURING CO., Chicago, Illinois, announces the appointment of Morgan P. Ellis as general sales manager. Mr. Ellis has been assistant general sales manager for the past 8 yr.

COLORADO FUEL & IRON CO., Pueblo, Colorado, expects to build a new 30,000 kw. power plant which will utilize pulverized coal as fuel. Wilfred Sykes, 6760 Stony Island Ave., Chicago, is the consulting engineer. The Gellert Engineering Co., of Chicago, is designing a large electrical precipitation plant for the same organization.

KNOX LAUNDRY CO., of Galesburg, Illinois, has installed a new plant consisting of two 100 hp. Frost boilers equipped with CoKal stokers, and one 50 hp. Frost engine.

A LICENSE HAS been granted by the Federal Power Commission to the Alabama Interstate Power Company, for the period terminating June 9, 1973, for a power project on the Tallapoosa River, Alabama. The project will consist of five developments above the so-called Cherokee Bluffs Unit for which a license has previously been issued, all to consist of concrete masonry dams designed to develop heads varying from 18 to 130 ft., and power plants having a total installed capacity of about 114,000 hp. The dams will create reservoirs of about 640,000 acre ft. total storage capacity.

OFFICIALS OF THE Missouri Power & Light Co., with headquarters at Mexico, Mo., have announced that the company has entered into agreement to acquire the properties of the North Missouri Power Co. The properties, principally electric generating stations and transmission lines, are located in 50 cities and towns in the north half of the state of Missouri. The company's plants and lines were built and developed by Major W. A. J. Bell and S. W. Henderson, of Excelsior Springs, Mo., through whom the merger is being effected.

Books and Catalogs

THE SUPERVISION AND MAINTENANCE OF STEAM-RAISING PLANT, by Charles A. Suckan; 342 pages, size 7¼ by 9¾ in., cloth, New York, 1924, price $8.00.

Many industrial plant managers still regard the power plant as a necessary evil rather than as a production department in which fuel, water and air are utilized as raw materials to make steam of a certain specified quality which is in itself a necessary raw material entering into the finished product. Its production, therefore, should be given as much consideration and attention as is given the remainder of the factory. The final product of this department may not be as tangible as the articles turned out by other departments but in many factory processes the cost of steam is as great if not greater than that of other materials used and should be considered from the same point of view. It is to assist the management in the proper appreciation of this important department that this book has been prepared. The volume consists of two parts, one on supervision and the other on maintenance. The first considers the operation or functioning of the power unit; attention to auxiliary appliances; care of what is called the subsidiary plant; the handling of coal, ash and water; and the management of the power plant staff. The second section takes up the upkeep of the power unit, overhauling the auxiliary plant and repairs to the subsidiary plant.

INDUSTRIAL OIL ENGINEERING, by John Rome Battle; second revised edition, 8 vol., 1141 pages, cloth, Philadelphia, 1923, price $10.00.

In this, the second revised edition of the handbook, the material has been revised and brought up to date. It is a

reference book of data relating to lubrication and industrial oils, including tables, general oil information, engineering and industrial requirements for the use, primarily, of oil and lubricating engineers. It includes the "Lubricating Engineer's Handbook," revised.

Unfortunately, in the early stages of the development of any new branch of engineering, a period must be passed through during which the available information on the subject and the standards, if they may be called such, of practice are indefinite. Industrial oil engineering has passed through such a period and is now fairly well defined as to the scope of its field and is rapidly standardizing the principles of its practice. It is these principles and standards that have been set forth in this handbook. It covers practically the whole field of oil from the refining of the crude to the application for lubrication, heat treatment and all the various items where the use of oil is a factor.

As is the case with all handbooks, its actual value is largely determined by the accessibility of the information contained. This is achieved here by the use of a quite detailed index covering some 65 pages.

DEVELOPMENT IN POWER STATION DESIGN, by Edwin Austin; 271 pages, size 7½ by 11 in., cloth, New York, 1924, price $9.00 net.

Since the early days when the central station first came into being many changes have been made in the design of power plants. Apart from the fact that the turbine has replaced the reciprocating engine in the great majority of stations, all kinds of apparatus, methods and equipment have been introduced to promote economy and efficiency; to increase reliability and to improve working conditions generally. It is these things that have been considered in this book. It is no ancient history; only modern developments are discussed. It covers power plant practice, particularly in England, but elsewhere as well.

This volume is the outcome of a series of articles on this subject which appeared in "The Engineer" (London) during 1921 and 1922. Of the topics treated, the pulverized coal plant, oil burning, low temperature carbonization, waste heat, air pre-heaters, evaporators, the high pressure steam plant, methods of ash handling, protective relays and instruments are of particular interest.

MCCORD RADIATOR & MFG. CO., 2587 East Grand Blvd., Detroit, Mich., has just published a booklet, covering class BA lubricators, describing the part lubrication plays in the dependable operation of heavy machinery, such as steam shovels, cranes, dredges, hoisting engines and coal and ore handling apparatus, and pointing out that continuity of service, reduced maintenance costs and satisfactory operation of equipment are due to efficient lubrication.

Another recent publication contains illustrations of the Class B lubricator adapted to small steam engines, oil engines, gasoline engines, air compressors, steam pumps and auxiliaries.

BUFFALO FORGE CO., 490 Broadway, Buffalo, N. Y., in their 8-page bulletin, No. 465, analyze the situation in the unit heater field and give complete information on the type of radiation to use under various conditions. The bulletin is illustrated with photos and drawings of installations, general design and details of construction.

STARRETT TOOLS are covered in the 1924 edition of a 352-page catalog just published by The L. S. Starrett Co., of Athol, Mass. A wide variety of small tools, such as micrometers, vernier calipers, squares, gages, tapes, etc., are illustrated and described.

THREE NEW CATALOGS have been issued by the Link-Belt Co., of Chicago, one of which is on portable loaders, one on electric hoists and the other on locomotive cranes. These catalogs describe the equipment in each case and are well illustrated, with application views which give an idea of the use of the apparatus under different conditions.

"HOW TO ORDER BRASS" is the title of a booklet which has recently been published by the Chase Metal Works, Waterbury, Conn. The purpose of the booklet is to point out what properties in brass are desirable for certain typical uses and to tell how to order such material so that the manufacturer will understand what is wanted.

"AIR FILTERS for Compressors and Internal Combustion Engines" is the subject matter of the bulletin now being distributed by the Midwest Air Filters Company, 100 East 45th St., New York City. Sufficient information is given so that it is possible to determine the proper size of filter for compressors and engines and the general problems of air filtering are discussed.

BRISTOL'S RECORDING GAGES for pressure-and vacuum are described in Catalog No. 1007 which has recently been issued by the Bristol Co., of Waterbury, Conn. Details of the instruments are illustrated in this bulletin which is made up of 84 pages.

"SCOVILL CONDENSER TUBES" is the title of a new booklet now being distributed by the Scovill Manufacturing Co., of Waterbury, Conn. The various processes used in making Admiralty and Muntz condenser tubing are described. Specifications for these two types of tubing, which cover the manufacture, chemical properties and tests, physical properties and tests, permissible variations in dimensions and workmanship and finish, are presented.

ENGBERG GENERATING SETS are described in Catalog No. 800, published by Engberg's Electric & Mechanical Works, St. Joseph, Mich. Features of the engine sets are illustrated and described.

"MATERIAL HANDLING & EQUIPMENT" is the subject of Catalog No. 21-M, issued by The Yale & Towne Manufacturing Co., of Stamford, Conn. This 100-page catalog takes up the use of chain blocks, electric hoists, hand traveling cranes and industrial trucks. Prices, dimensional data and details of parts are included with the discussions of application.

U-RE-LITE HANDBOOK is primarily a description of the line of U-Re-Lite devices for protecting circuits and machines against overload and no-voltage. It is developed, however, into a broad discussion of the why and how of such protection. Full information is given as to the various types of these circuit breakers, their sizes, how to install and adjust them and what they will do. The book, which is a bound volume of 95 pages, well represents The Cutter Co., of Philadelphia, Pa., by whom it is published and from whom it may be obtained by writing them at 19th and Hamilton streets.